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A TAXONOMIC STUDY OF THE SOLDIER FLY LARVAE OCCURRING IN AMERICA NORTH OF MEXICO (DIPTERA: STRATIOMYIDAE)

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ABSTRACT

A taxonomic treatment is presented for larvae of Stratiomyidae. Data on biology and morphology provide the basis for arranging the species of this family into eight subfamilies as follows: Solvinae, Chiromyzinae, Beridinae, Sarginae, Hermetiinae, Adoxomyiinae, Pachygasterinae and Stratiomyinae. Evidence is presented to show that these subfamilies represent four main lines of evolution.

The system of classification based on characteristics of the adults is contrasted with one based on characteristics of the larvae, with two major areas of disagreement being noted: 1), the taxonomic position of the genus Solva; 2), the relationships of the genera in the subfamily Clitellarinae (of authors). Evidence is presented which indicates that Solva should be included within this family. A study of larvae within the Clitellarinae resulted in the transferral of Dieuryneura to the Beridinae, Adoxomyia to the Cyphomyiinae, with a resultant name change and the remaining Clitellarinae genera were placed in the Stratiomyinae.

Larvae of 55 species are described and illustrated, 31 for the first time. These represent the eight subfamilies and 26 of the 37 genera known to occur in America north of Mexico. Keys are presented for distinguishing among larvae at the subfamily, generic, subgeneric and specific levels.

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I. INTRODUCTION

The Stratiomyidae or soldier flies are represented in America north of Mexico by approximately 237 species distributed through 37 genera. Previous to this study larvae were known or described for only 21 species representing 15 genera. In addition to this lack of adequate descriptions as well as keys, few attempts at classification have been made and a phylogenetic treatment of the larvae has never been presented.

The present study has been undertaken with several goals in mind: first, to rear and describe as many species as time allows; second, to redescribe all previously described larvae of North American species; and third, on the basis of larval characters to attempt to define the various taxonomic units and show phylogenetic relationships within, and between, this family and other closely related families.

Any attempt to establish subfamily and generic limits must be regarded as tentative. This is especially true in this study, as larvae of so many species of Stratiomyidae remain unknown. No doubt as more species are reared, changes will have to be made in keys and definitions of taxa.

The keys have been prepared mainly for identification of last instar larvae. If earlier instars are known, they have been either included in the key or a separate description has been given or both. Because pupation takes place within the last larval skin, the puparium can be identified with the keys to the larvae.

II. HISTORICAL RÉSUMÉ

During the period from 1720 to the present numerous papers have been written on various aspects of stratiomyid natural history as well as on morphology and physiology of the larvae. Rather than attempt to digest this voluminous literature in a few paragraphs I have appended a chronological list of these works together with those papers that have already been mentioned in this résumé. In actual practice this list is a historical record of all phases of work that have been carried on with the larvae of Stratiomyidae.

Studies on the biology and systematics of larval Stratiomyidae can be divided into two rather distinct periods.

The first period (1720-1868) was devoted to the description of local faunas. In most instances larvae were associated with adults through rearing so that correct identifications were obtained. However, no attempts were made at classification nor were other generalities presented.

The second period, which was initiated by Brauer (1869), was characterized by the incorporation of biological features and the characteristics of the immature stages in classification. Using Schiner's classification (1868) based on adults, Brauer demonstrated that the immature stages of Diptera could be used as a check against an already existing system of classification. Although Brauer did not or was not able to organize the Stratiomyidae into its component genera, he did realize that the Stratiomyidae, Tabanidae, Xylophagidae, Leptidae and Coenomyidae were closely allied and placed them in the tribe Cyclocera under the Orthorrhapha-Brachycera.

Brauer (1883) once again reviewed the characters of dipterous larvae and on the basis of differences in head capsules established a new classification in which the Stratiomyidae and Xylophagidae were considered as separate families but placed together in the Notacantha. In this same paper Brauer divided the Stratiomyidae into its various genera and listed the larval characters for each genus.

Austen (1899) presented a clear and concise review of the problem regarding the classification of the genus Solva, subsequent to which the majority of dipterists have considered Solva to be located in the Solvinae, a subfamily within the Stratiomyidae. (For further details see page).

Malloch (1917) was the first person to systematically arrange the North American Stratiomyidae on the basis of larvae. As might be expected numerous genera were omitted since many larvae had as yet not been described.

Johannsen (1922, 1935) continued the work of Malloch. He added several new descriptions of larvae and supplied much of the data on biology which we have today.

The most recent contribution to the classification of stratiomyid larvae has come from Willi Hennig. In his outstanding work "Die Larvenformen der Dipteren" the species are listed for each genus and their distribution given by zoogeographical region. In addition he has included notes on biology for nearly all the species mentioned.

III. MATERIALS AND METHODS

Collecting and Rearing

A suitable technique for removing larvae from various substrates was developed (McFadden, 1961) and specimens thus obtained were divided into two groups: one for rearing, the other to be preserved.

Larvae were killed and preserved in 70% alcohol without additional treatment. In the case of large specimens the alcohol was changed after a month had lapsed.

Rearing was simplified by collecting in the spring when larvae were usually in the last instar, about to pupate, or had pupated already. Larvae and pupae held for rearing were placed in five dram vials fitted with cotton stoppers. A small amount of the substrate in which the animal was found was placed in the vial before adding the specimen. Distilled water was added occasionally to maintain moist conditions. Larvae and pupae were always reared individually so that emerging adults or parasites could be associated with the respective larval or pupal skin. The adults were then identified and associated with the larvae that had not been reared and thus the identity of these larvae was determined. This is by no means a foolproof system for identification but in most instances it can be relied upon because of the gregarious nature of the larvae.

Special Techniques

In observing preserved specimens I frequently found that many of the morphological characters, which are used in distinguishing the various taxa, were obscured by deposits of calcium carbonate and

environmental debris. The larvae were quickly cleared of most of the debris by soaking them in 10% hydrochloric acid (Lundbeck, 1907 and Johannsen, 1935). Active effervescence always accompanied this treatment.

The head of the larva was prepared for study by removing it from the larva and placing it in a test tube containing 2% potassium hydroxide. The tube was then placed in a beaker of water, the latter being boiled slowly for two hours. The heads were then washed in glacial acetic acid, dissected and mounted on a slide. Photomicrographs were taken of the mounted heads and illustrations were prepared using the technique described by Howden (1955).

Measurements

Measurements were taken with a ruled ocular in a stereoscopic microscope under magnifications of 6X or 50X. The distance between the lines of the ocular viewed at 6X is 0.167mm.; at 50X, 0.019mm.

The number of specimens given under the heading "Material Examined" represents the actual size of the sample upon which the mensural data are based.

Abbreviations

The names of the institutions that have loaned material upon which mensural data are based, are abbreviated in the manner given below: California Academy of Sciences (C.A.S.); The Canadian National Collection (C.N.C.); University of Colorado (U.C.); Cornell University (C.U.); University of Delaware (U.D.); Dominion Research Laboratories at Saskatoon, Saskatchewan (D.R.L.S.); Illinois Natural History

Survey (I.N.H.S.); University of Kansas (K.U.); Louisiana State University (L.S.U.); University of Massachusetts (M.S.C.); M.W. McFadden Collection (M.W.M.); North Carolina State University (N.C.S.); Ohio State University (O.S.U.); United States National Museum (U.S.N.M.); Washington State University (W.S.U.).

IV. BIOLOGY

The following discussion comprises a review of the literature on the biology of the Stratiomyidae. An attempt has been made to present a general life history and accordingly literature dealing with a particular stage or aspect of the life history has been included under the respective heading.

Irwin-Smith (1920, 1921) was the first person to achieve some success in rearing a species in the laboratory. Although she was able to obtain a cycle from larva to larva she was unable to determine the length of time of the larval stage. More recently, Furman, Young and Catts (1959) reported that newly hatched larvae of *Hermetia illucens* require two weeks or longer to attain full growth under laboratory conditions. The number of instars was not mentioned. It was also reported that the pupal stage may last from two weeks to five months. No data are available on the life span of adult stratiomyids.

Eggs

Eggs are usually laid in early spring by females that have overwintered as larvae. When first laid the eggs are pale yellow but become progressively darker as the hatching date approaches. The actual time required for hatching is two to three weeks.

Hart (1895) mentions that the eggs of *Odontomyia* are "cigar-shaped", but this apparently is not the case throughout the family. Wesenberg-Lund (1943) reports that the eggs may be flattened or highly arched or in the form of a "regular egg". In addition, he mentions that the eggs are usually placed in a distinct group or clump (the number

probably varying with the species), on vegetation overhanging water in the case of the aquatic forms or on decaying organic matter in the case of terrestrial forms. Wesenberg-Lund also mentions that the eggs of Stratiomyidae are difficult to distinguish from those of Tabanidae.

Larvae

Newly hatched larvae were noted by Irwin-Smith (1921) to molt as soon as they emerged from the egg. Active feeding commenced immediately. As stated previously, the duration of the larval state is unknown but the larvae of the majority of the northern Nearctic species appear to be fully mature by fall. These mature larvae are probably the overwintering stage, as pupation does not occur until the following spring.

Larvae in each of the subfamilies exhibit a varying degree of similarity with respect to their feeding habits (James, 1960 B), but there is considerable variation in habitat selection by species within the subfamilies. Thus we have papers by Packard (1871), Lucas (1879), Griffith and Packard (1882), and Brues (1924, 1928 and 1932) recording the occurrence of larvae in salt water and in hot water of springs and lakes. Pearson (1883) reported a larva that was found on an exposed part of ocean beach and Florentin (1899) found a great mass of larvae in excessively saline pools.

The sum of our knowledge in condensed form on habitats for the larvae of the North American genera of Stratiomyidae is presented in Table I. Except for those genera such as Actina, which are only known from some other part of the world, the references are primarily to North American workers. It is hoped that this table will not only be an aid to

collecting larvae but will also be a guide to the needs for future studies within the family. Additional information on biology of the larvae is given under the species descriptions.

TABLE I

HABITATS OF STRATIOMYID LARVAE OCCURRING IN AMERICA NORTH OF MEXICO

Genus	Aquatic	Terrestrial	HABITAT	References
Solva *		X	under bark of trees; in rotted logs	Townsend 1893 Malloch 1917 Johannsen 1922 Greene 1926 Peterson 1951 Hennig 1952
Altermetoponia		X	sod	Irwin-Smith 1920
Allognosta		X	decaying organic material	Malloch 1917 Johannsen 1922
Actina		X	decaying plant and animal material	Fuller 1934
Beris		X	decaying leaves; under bark of fallen trees; in moss?	Williston 1908 de Meijere 1916 Lenz 1923
Exodontha		X	rotten wood under large boulders	

* Genera arranged by subfamily as given on page 35.

TABLE I cont'd

Genus	Aquatic	Terrestrial	HABITAT	References
Sargus		X	in decaying plant and animal material; in excrement	Westwood 1840 Lundbeck 1907 Williston 1908 Malloch 1917 Johannsen 1922 Peterson 1951 Hennig 1952
Dieuryneura		X	in decaying plant tissue	
Ptecticus		X	in decaying organic material	Lindner 1928 Hennig 1952
Microchrysa		X	in decaying organic material; in excrement	Lundbeck 1907 Malloch 1917 Johannsen 1922 Seguy 1926 Hennig 1952

TABLE I cont'd

Genus	Aquatic	Terrestrial	HABITAT	References
Chloromyia		X	in decaying organic material	Brauer 1883 Cornelius 1860 Lundbeck 1907 Seguy 1926
Dicyphoma		X	in damaged and decaying cacti	James 1962
Cyphomyia		X	in decaying plant material	James 1957
Hermetia		X	in decaying organic material; in excrement	Williston 1908 Malloch 1917 Johannsen 1922 Copello 1926 James 1935 James 1947
Oxycera	X		on margins of streams, lakes and ponds	Heeger 1856 Lundbeck 1907 Johannsen 1922 Lenz 1923 Johannsen 1935

TABLE I cont'd

Genus	Aquatic	Terrestrial	HABITAT	References
				Wesenberg-Lund 1943
Euparyphus	X		on margins of aquatic environments - usually associated with mossy conditions	Johannsen 1922 Johannsen 1935 Wesenberg-Lund 1943 Peterson 1951 James 1960 B
Caloparyphus	X		in bog or swamp areas; usually associated with mossy conditions	Quist (thesis) James 1960 B
Nemotelus	X		under debris at margins of lakes and ponds; frequently found in halophile conditions	Haliday 1857 A Lundbeck 1907 Malloch 1922 Johannsen 1922 Lenz 1923 Johannsen 1935 Wesenberg-Lund 1943 Hanson 1958 James 1960 B

TABLE I cont'd

Genus	Aquatic	Terrestrial	HABITAT	References
Stratiomys	X		on margins of lakes and ponds, usually in association with Typha spp.; occasionally in hot springs or saline habitats	Hart 1895 Johnson 1895 Miall 1895 Lundbeck 1907 Williston 1908 Malloch 1917 Johannsen 1922 Johannsen 1935 Peterson 1951 James 1960 B
Hedriodiscus	X		on margins of lakes and ponds	James 1960 B
Odontomyia	X		in much the same habitat as Stratiomys	Hart 1895 Johnson 1895 Lundbeck 1907 Williston 1908 Malloch 1917 Johannsen 1922 Johannsen 1935 Peterson 1951

TABLE I cont'd

Genus	Aquatic	Terrestrial	HABITAT	References
				James 1960 B
Myxosargus	X		no data available	
Berkshiria		X	under bark of trees	Kraft and Cook 1961 Cook 1953
Zabrachia		X	under bark of coniferous trees	Malloch 1915 Malloch 1917 Kraft and Cook 1961
Neopachygaster		X	under bark of coniferous and deciduous trees	Malloch 1917 Cook 1953 Kraft and Cook 1961
Eupachygaster		X	under bark of trees	Malloch 1917 Kraft and Cook 1961
Pachygaster		X	in tree holes; in tree crotch debris and in hollow trees	Kraft and Cook 1961

Pupae

The stratiomyid pupa, surprisingly, is much smaller than the puparium, often being only one third the total length of the latter.

At the onset of pupation the mature larva becomes rigid, the integument hardens and the apical segments are usually in a distorted position. The pupa itself is enclosed in a silky cocoon secreted by the salivary glands and occupies only the anterior end of the puparium. Miall (1895) reports that earlier workers often mistook the pupa to be a parasite which had devoured the larva.

Because of the shrinkage of the pupa an air space is formed within the puparium and thus the aquatic pupal stage becomes buoyant. As a result the pupa floats on the surface of ponds or other bodies of water until eventually it is either blown by the wind or carried by the action of waves to the shore where it remains with other debris until the adult emerges.

At the time of emergence the puparium splits not only along the dorso-median line of the second abdominal segment, in the manner of the Nematocera, but also transversely on the same segment in the manner of the Cyclorrhapha.

Adults

Malloch (1917) and Johannsen (1935) have stated that adult stratiomyids, of both terrestrial and aquatic forms, may be seen flying about in areas where species of Umbelliferae and Compositae are in flower, or resting on vegetation that is close to water. Although there is relatively little information on feeding habits of the adults, the

regularity with which they are seen on vegetation correlates with Lundbeck's observation (1907) that the adults feed on "plant juices" (nectar?).

The more commonly seen adults which represent species of Stratiomys and Odontomyia are robust in appearance and are good fliers, but there are many species in other genera which lack one or both of these attributes. Other species, especially in the genus Sargus, are able to hover about vegetation in the manner of a syrphid fly.

Adults may be collected by sweeping in grassy meadows, in bog areas and in sedges, cattails, and other vegetation along the margins of lakes, streams and ponds.

Parasites and Predators

Several investigators have observed parasites and/or predators attacking larvae of Stratiomyidae. In Table II, I have presented this information in condensed form and have added, as well, my own observations.

TABLE II

PARASITES AND PREDATORS OF STRATIOMYID LARVAE OCCURRING IN AMERICA NORTH OF MEXICO

Parasite or Predator	Host	Reference
Coleoptera:		
Coccinellidae		
Megilla maculata	eating egg mass of Odontomyia sp.	Hart 1895
Hymenoptera:		
Pteromalidae		
Rhicnocoelia n.sp.+	Odontomyia sp.	McFadden
Genus sp.	Stratiomys sp.; Chloromyia formosa	Lundbeck 1907
Eulophidae		
Tetrastichus sp.	Microchrysa polita	Lundbeck 1907
Chalcidae		
Chalcis barbara	Stratiomys norma	Hart 1895
Chalcis microgaster	Odontomyia cincta; Odontomyia sp.; Odontomyia vertebrata; mutilating egg mass of Odontomyia sp.	Hart 1895
Ichneumonidae		
New genus,++ n.sp.	Stratiomys sp.	McFadden

+ Taxonomic status as given by B.D. Burks, United States National Museum
++ Taxonomic status as given by L.H. Walkely, United States National Museum

TABLE II cont'd

Parasite or Predator	Host	Reference
genus, n. sp.	Nemotelus sp.	Lundbeck, 1907
genus sp.	Sargus sp.	Lundbeck, 1907

V. MORPHOLOGY

Several notable investigations on the morphology of the Stratiomyidae have been made and have been concerned with the nervous system, the respiratory system, the head capsule and the integument. While the quality of this work is very good the quantity, or more precisely, the number of different species investigated, leaves much to be desired. In this section an attempt has been made to incorporate previous work with my own studies into a discussion of the major morphological characteristics of the larvae, both external and internal.

External Features

Integument

The integument of a stratiomyid larva is composed of many facets, some of which are distinctly hexagonal and others vary in size and shape. This faceted appearance has caused students of Stratiomyidae to refer to the integument as being shagreened*.

Many early investigators (Miall, 1895; Leydig, 1860; Müller, 1925 and Kruper, 1930) noticed the presence of these facets and explained their appearance by saying that they represented the upper surface of the "calcareous nails" which are so evident in a cross-section of the integument (Fig. 7). These nails are composed of calcium carbonate but

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* This word is derived from the near-eastern word shagreen, which is a type of uncured leather prepared in that area. As it is used here it refers to the multi-faceted integument which no doubt brought to mind the type of leather mentioned above.

how they are formed is unknown. Earlier workers were of the opinion that the calcium deposits were secreted, most probably by the malpighian tubules but in an unknown manner. Richards (1951), however, is of the opinion that the calcium deposits are laid down on the external surface of the integument as a result of carbon dioxide diffusing out through the integument into a calcium rich medium (water). Richard's theory, however, will not explain the development of the "nails" under the acid conditions in which many species of stratiomyid larvae occur, nor will it explain the development of the "nails" in terrestrial species.

The "nails" provide the larva with a strong but flexible armor. To test its resistence to attack one needs only to try to section it. Flexibility is obtained by the pyramidal shape of the "nails" which allows the integument to bend.

The Head And Its Appendages

The total length of the head is always greater than the width. This statement may seem misleading for the head is permanently retracted approximately one half of its length into the thorax (Fig. 4).

Distinctive eye prominences are situated on the lateral margin of the ocular lobes. Located between the two ocular lobes is the clypeus which is limited by the frontal sutures. At the distal end of the clypeus is the labrum, a structure which is not always clearly defined posteriorly by the clypeolabral suture. The mandibular-maxillary complex is located in the pocket formed by the labrum and the extensions of the ocular lobes. The complex itself is formed by the fusion of the mandibles and the maxillae as the name suggests. It is so articulated

that movement is in a plane perpendicular to the long axis of the body. Cook (1949) states that the mandibular-maxillary complex is used for sweeping food into the oral cavity rather than for chewing.

The two-segmented antennae are located near the apex of the ocular lobes but the exact position varies with the species as does the size and shape.

On the ventral surface of the head (Fig. 5) there is a membranous area which outlines the labium. The large posterior part of the labium is the submentum. Directly anterior to the submentum is the prementum and the palatum. The latter structure as pointed out by Cook (1949) is apparently an adaptation for rooting up material. Cook also reported that labial palpi and a hypopharynx are lacking in stratiomyid larvae. The arrangement of the previously mentioned structures is shown in Fig. 6. The most important feature illustrated here is the arrangement of two sclerotized plates which are located beneath the pharynx at the posterior end of the head capsule. These structures function as a mortar and pestle, grinding up the food material that is swept into the mouth by the mandibular-maxillary complex (Bischoff, 1925; Cook, 1949). The bowl-like mortar is very heavily sclerotized and convoluted while the pestle, which is formed by the floor of the pharynx, is modified in the form of a heavy, corrugated plate and fits into the bowl of the mortar.

If the mortar and pestle do indeed perform the task of grinding the food it seems inconceivalbe that stratiomyid larvae could be predaceous on other larvae as has been reported, especially when the size of the oral cavity is taken into consideration.

Thorax

The thorax is composed of the first three body segments posterior to the head. The noteworthy characteristics found here are: 1) the prothoracic spiracles which vary in size and shape; 2) the chaetotaxy; 3) the shape of the segments, which seem to become broader towards the metathoracic segment. Stratiomyid larvae are without legs or prolegs.

Abdomen

This tagma consists of the eight body segments posterior to the metathoracic segment. They are similar in form to the thoracic segments but differ in chaetotaxy and in the occurrence of special organs or structures. Several genera can be distinguished by the markings or color patterns that occur on the thoracic and abdominal segments.

The first and second segments are usually the broadest. The remainder of the segments either taper toward the apical segment (aquatic species) or several segments are parallel-sided and the remaining taper toward the apical segment (terrestrial species). At the extreme end of the apical segment, which is often much longer than it is wide, (Fig. 108) especially in the aquatic species, is located a transverse fissure which houses the spiracular chamber. In the genus Nemotelus, however, the spiracular chamber is located on the dorsum of this segment.

A few aquatic genera, notably Euparyphus and Odontomyia, possess strongly curved sclerotized hooks or spines, as they have some-

times been called, (Fig. 123). They are usually on the venter of the seventh abdominal segment but in the genus Hedriodiscus they are on the venter of the sixth segment as well. A remarkable feature of the spines is that they curve forward towards the head. This arrangement would seem to present some difficulty in forward movement, but this has not been observed. Previous workers (Wesenberg-Lund, 1943; Lenz, 1923) have reported that the hooks serve as anchors to keep the larvae from being swept away by fast flowing currents. This statement may be partially correct but I have observed this type of larva in shallow pools which had only convection currents.

Internal Features

Digestive System

The digestive system has little to offer in the way of taxonomic characters other than the characteristic shape of the gut which is long and highly convoluted. Except for the mortar and pestle, there are no sclerotized areas present in either the foregut or the hindgut.

Malpighian Tubules

The malpighian tubules are filled with a whitish, semi-liquid material that is reported to be primarily composed of calcium carbonate. This material may be in some manner associated with the calcium carbonate that is secreted in the integument.

Respiratory System

Stratiomyid larvae have frequently been described as peri-

pneustic, but it is doubtful that they are functionally so. They appear to be metapneustic or in some cases amphipneustic. The lateral spiracles almost always are minute and difficult to detect, especially in the later instars. The only spiracles that function continually are the terminal or posterior spiracles.

The spiracular chamber contains the ends of the two main trachealtrunks. In the aquatic forms the lips that form the opening to the chamber are fringed with long hydrofuge setae that enable the larvae to remain suspended from the surface of water for indefinite periods of time while the spiracles are open to the atmosphere. When submerged these setae also aid in respiration by enclosing an air bubble which they trap in the process of submerging.

Using the work of Whitten (1959) as a guide, the tracheal system of four genera (2 aquatic and 2 terrestrial) was examined for possible taxonomic characters. The tracheal system of each larva has the same general pattern as that given by Whitten for brachycerous larvae and consequently cannot be used as a distinguishing character beyond the suborder.

Nervous System

Although there have been several studies made on the nervous system of a few species of stratiomyid larvae the results appear to have little consequence from a taxonomic standpoint, (Viallanes, 1882 A and B, 1885; Kunckel d'Herculais, 1879 and Henneguy and Binet, 1892).

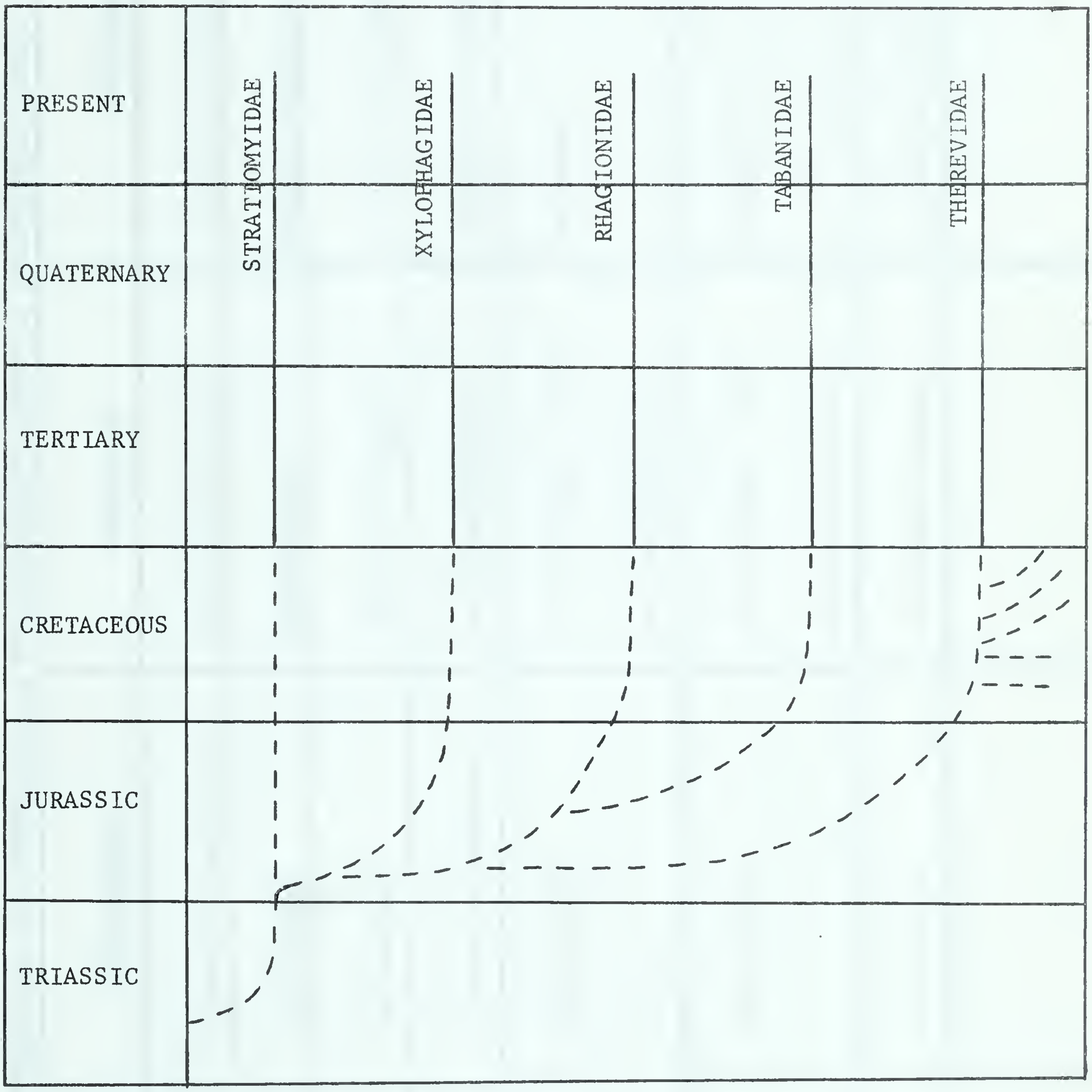
VI. PHYLOGENY

Handlirsch (1908) postulated that the Stratiomyidae arose in Jurassic times from a primitive tipulid stock which had evolved to the point where it more closely resembled the Xylophagidae than the Tipulidae (Fig. 1). The families most like the Stratiomyidae, the Xylophagidae and the Rhagionidae (often combined to form the Leptidae) are similar to members of the stratiomyid subfamily Solvinae, but only in the adult stage (wing venation, spurs on tibiae, etc.). From the Rhagionidae or Leptidae arose the Tabanidae and Therevidae and in turn, this line of descent led directly to the more advanced Diptera (Handlirsch, 1908; Lindner, 1937 and Bischoff, 1925).

The most primitive subfamily in the Stratiomyidae is the Solvinae. Characters that occur in the immature stages of this subfamily and which I consider to be primitive are: 1) integument only partly shagreened, 2) generalized type of mouthparts, 3) incompletely enclosed pupa, and 4) type of habitat, which is usually under bark or in rotten logs. Characters of the adults are equally primitive.

From this primitive subfamily four lines appear to have evolved, one of which represents a continuation of the basic type with slight modifications in morphology (Solvinae - Beridinae - Adoxomyiinae - Pachygasterinae). The other lines represent a divergence towards different ecological zones in the larval stage: one, to an aquatic or semi-aquatic mode of life (Stratiomyinae); another to life in a rich, soft, food source such as animal excrement and decaying organic matter (Sarginae, Hermetiinae); and another line, represented by Altermetoponia rubriceps (Macquart) which lives in sod (Chiromyzinae).

Fig. I



Proposed Phylogeny for the Family Stratiomyidae

(after Handlirsch, 1908)

TABLE III

ECOLOGICAL AND MORPHOLOGICAL SPECIALIZATIONS FOUND IN STRATIOMYID LARVAE

SUBFAMILY	ENVIRONMENT	NUTRITION	MOUTHPARTS
Solvinae	terrestrial-arboreal	micropantophagous	cylindrical brushes present
Chiromyzinae	terrestrial	phytophagous	brushes and setae absent
Beridinae	terrestrial	micropantophagous	cylindrical brushes present
Pachygasterinae	terrestrial-arboreal	micropantophagous	cylindrical brushes present
Sarginae	terrestrial	coprophagous, sapro-necrophytophagous	degenerate
Hermetiinae	terrestrial	coprophagous, sapro-necrophytophagous	degenerate
Adoxomyiinae	terrestrial	saprophytophagous	cylindrical brushes present
Stratiomyinae	aquatic	micropantophagous	cylindrical brushes absent

As previously indicated, the environment in which the larvae live, their feeding habits and the type of mouthparts are closely allied and provide us with an insight into the evolution of the family. Table III illustrates the distribution of these characters through the subfamilies. In an attempt to show degree of relationship, 13 characters (larval and adult) were analyzed and given an arbitrary numerical value (for details of the technique, see James, 1953). A list of the characters and their numerical values follow.

A. Habitat of larva

1 aquatic or semi-aquatic

2 terrestrial

3 arboreal (close association with trees)

B. Food of larva

1 aquatic microorganisms

2 plant roots

3 decaying organic matter

C. Adult antennae

1 annulate

2 intermediate (both types present)

3 aristate

D. Spinose condition of scutellum in adult

1 spines present

2 intermediate (both types present)

3 spines absent

E. Abdominal segmentation of adult

1 seven segments

2 five segments

F. Labium of larva

1 well developed

2 not well developed

G. Distribution of maxillary setae in larva

1 setae absent

2 setae present, located in notch

3 setae present, linear arrangement

4 setae present, other arrangement

H. Types of maxillary setae in larva

1 cylindrical brushes

2 cylindrical brushes absent or not cylindrical

I. Transverse series of dorsal setae with accompanying setae in larva

1 extra setae present

2 extra setae absent

J. Posterior spiracles of larva

1 with coronet of setae

2 without coronet of setae

K. Anal armament of larva

1 large teeth anterior to anal opening

2 large teeth absent

L. Body conformation of larva

1 attenuate

2 parallel-sided

M. Mandibles of larva

1 well developed

2 not well developed

3 absent

The results are shown graphically in Fig. 2. A phylogenetic tree is presented in Fig. 3 which represents the sum of the similarities and differences among the subfamilies and indicates relationships of the extant species.

The Beridinae and succeeding subfamilies of the Stratiomyidae probably arose from a group of the subfamily Solvinae which had developed a completely shagreened integument. This separation was no doubt subsequently strengthened by two changes in the ecological requirements of beridine larvae. The first consisted of a change in habitat (larvae of Beridinae are not found in the same habitat as larvae of Solvinae), and the second was a change in food preference, as is evidenced by larvae of _Actina incisuralis_ and _Dieuryneura obscura_.

On the basis of similarity of mouthparts, the Adoxomyiinae and the Pachygasterinae appear to have arisen from the beridine stock. The former represents a radiation into a new ecological zone, and the latter represents an evolutionary improvement for living in an already occupied niche. Adoxomyiine larvae have mouthparts much the same as beridine larvae except for the labium, which has become more sclerotized and spatulate in the former. This change in the labium is probably an adaptation for feeding on the pulpy flesh of succulents.

The subfamily Pachygasterinae represents an advanced group on the basis of adult characters, but the mouthparts of the larvae are similar to those found in the larvae of Solvinae and Beridinae. In addition, pachygasterine larvae are found under the bark of trees as are

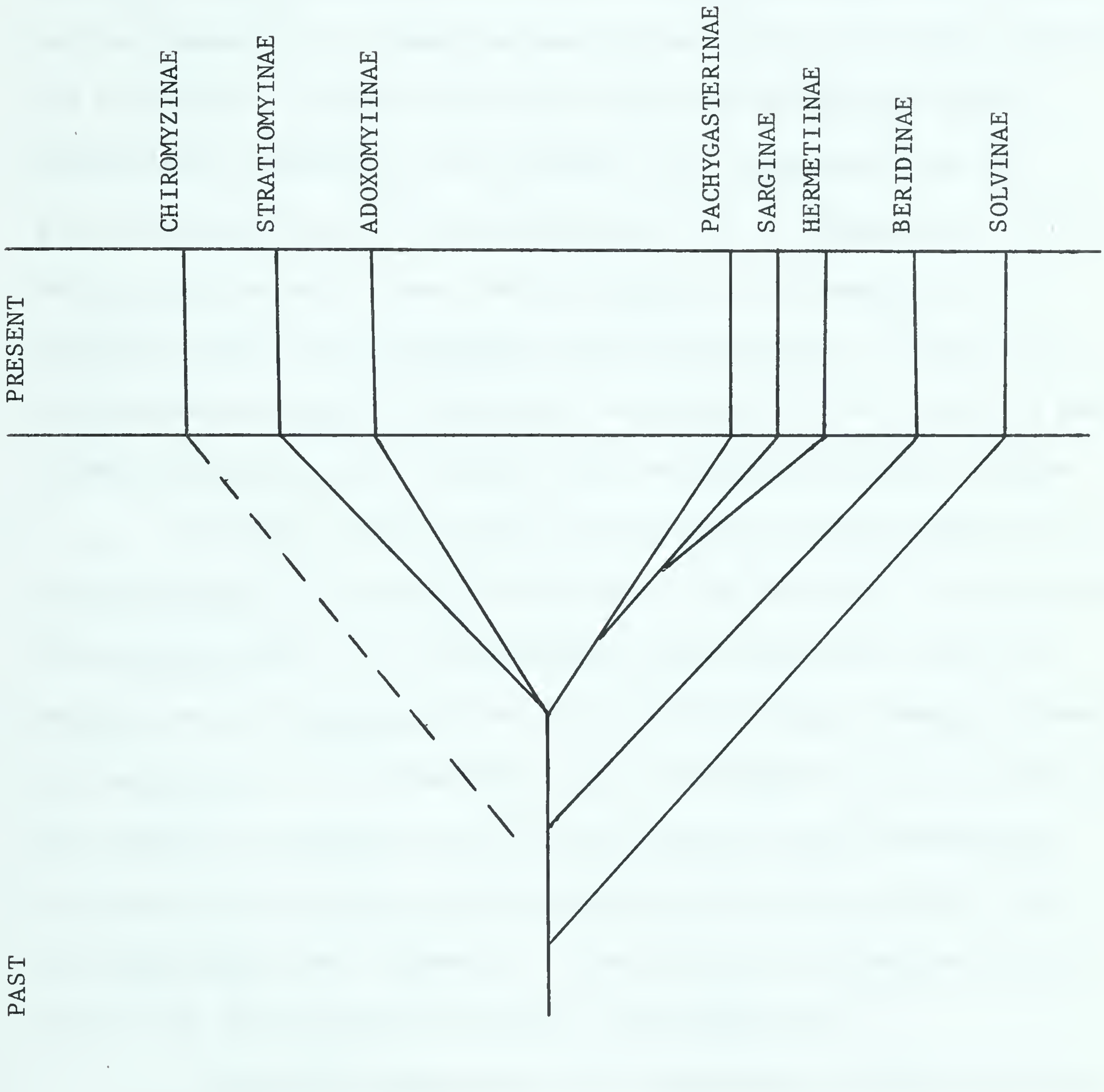
Fig. 2

☆ - 0 - 2 ★ - 3 - 5 ○ - 6 - 8 ● - 9 - 11	SOLVINAE	BERIDINAE	CHIROMYZINAE	SARGINAE	HERMETIINAE	PACHYGASTERINAE	ADOXOMYIINAE	STRATIOMYINAE
SOLVINAE	☆	★	●	●	●	★	★	●
BERIDINAE		☆	●	○	○	★	★	●
CHIROMYZINAE			☆	○	○	●	●	●
SARGINAE				☆	★	★	○	●
HERMETIINAE					☆	○	○	○
PACHYGASTERINAE						☆	★	○
ADOXOMYIINAE							☆	○
STRATIOMYINAE								☆

Graphic representation of subfamily relationships

The symbol in each square represents a range of numerical values. Each numerical value is the sum of the differences in 13 characters (33 variates) between a pair of subfamilies. Maximum values indicate maximum differences and distant relationships; minimum values indicate minimum differences and close relationships.

Fig. 3



Proposed phylogeny for the eight stratiomyid subfamilies

larvae of Solvinae. During the course of time, however, the chaetotaxy and size of the larvae have evolved.

The Sarginae appear to have arisen from the pachygasterine stock, but this must have occurred at a very early period since there are few characters in common between the two groups. The main differences are ecological. Sargine larvae are restricted to decaying organic material and consequently the mouthparts have degenerated and are quite distinct from any other group except for the Hermetiinae. This latter group orobably arose from the Sarginae. The mouthparts of hermetiine larvae have undergone extreme degeneration. There are no sclerotized areas and the setae that are present are confined to a small linear patch on the inner margin of the mindibular-maxillary complex.

The last subfamily, the Stratiomyinae, has few characters in common with any of the extant subfamilies. On the basis of the relationships shown in Fig. 2 the Stratiomyinae could have arisen from the Hermetiinae, the Pachygasterinae or the Adoxomyiinae. However, because the mouthparts of the Hermetiinae are so degenerate it is not likely that this subfamily represents the ancestral stock of the Stratiomyinae. Characters of the adults and mouthparts of the larvae eliminate the Pachygasterinae also. Therefore I consider the Stratiomyinae to have arisen from the remaining subfamily, the Adoxomyiinae.

Because the Chiromyzinae are represented in America north of Mexico by only _Altermetoponia rubriceps_, an introduced species, no further consideration is given to the phylogeny of this subfamily.

VII. CLASSIFICATION

The classification of the Stratiomyidae as presented here is based upon the opinions and conclusions drawn from the relationships of the subfamilies presented in the previous section. As might be expected, the new system differs somewhat from the classification of James (1960 A) which is based upon adult characters only. A comparison of the two systems is given below.

James	McFadden
1. ____________	1. Solvinae - Solva
2. Chiromyzinae - Altermetoponia	2. Chiromyzinae - as in James.
3. Beridinae - Allognosta, Actina, Beris, Exodontha	3. Beridinae - Dieuryneura added to James's list.
4. Sarginae - Sargus, Ptecticus, Microchrysa, Chloromyia*, Merosargus*	4. Sarginae - as in James.
5. Cyphomyiinae - Cyphomyia Dicyphoma	5. Adoxomyiinae - Adoxomyia added to James's list.
6. Hermetiinae - Hermetia	6. Hermetiinae - as in James.
7. Clitellarinae - Adoxomyia, Dieuryneura, Euryneura*, Oxycera*, Euparyphus, Caloparyphus, Akronia*, Camptopelta*, Nemotelus, Euryneurasoma*,	7. See under Beridinae, Adoxomyiinae and Stratiomyinae.
8. Stratiomyinae - Stratiomys, Hoplitomyia*, Nothomyia*, Labostigmina*, Myxosargus,	8. Stratiomyinae - Stratiomys, Hedriodiscus, Odontomyia, Myxosargus, Euparyphus,

*Anoplodonta**, *Hedriodiscus*,
Odontomyia

Caloparyphus, *Nemotelus*

9. Pachygasterinae - *Neopachygaster*,
Eupachygaster, *Zabrachia*,
Pachygaster, *Berkshiria*

9. Pachygasterinae - as in James

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* Represents genera not seen in immature stages and consequently not placed in my classification.

There are two major points of difference between this arrangement and that of James. First, the latter author does not include *Solva* in the Stratiomyidae but several other workers, notably Westwood (1840), Brauer (1883) and Osten Sacken (1882), have pointed out that it should be placed in this family. In 1899 Austen presented a summation of previous work concerning the classification of *Solva* and came to the conclusion, "that *Solva* represents a primitive ancestral form of Stratiomyidae, given off from the common stem after the evolution of the characteristic type of larva and mode of pupation, but before the assumption on the part of the imago of the equally characteristic features (venation, spurless tibiae, etc.) exhibited by the more specialized types of the family." I accept this classification for the genus *Solva*. (For detailed explanation see page).

A second area of disagreement between the two systems is in the classification of the Clitellarinae. Although I have not seen the immature stages for all of the genera listed by James, I have seen a sufficient number of specimens to warrant the changes that I have made.

A study of the mouthparts revealed that there were three distinct types present in this one subfamily. One type was found in the genus Adoxomyia. The mouthparts of the species in this taxon are very familiar to those found in the larva of Cyphomyia. In addition, larvae of both genera are known only from wounded or decaying succulents in North America. Consequently Adoxomyia was transferred to the Cyphomyiinae and because the use of the name Adoxomyia as the stem for the name of a suprageneric category predates the use of the name Cyphomyia for that purpose, the subfamily name was changed accordingly.

A similar taxonomic change was effected after a comparison was made between the mouthparts of Dieuryneura and members of the subfamily Beridinae.

The larvae of the remaining genera in the Clitellarinae are either aquatic or semi-aquatic and the mouthparts are similar to the genera originally placed in the Stratiomyinae. These two facts by themselves give sufficient cause to unite the genera in a single subfamily, but in addition, all of the genera, except Nemotelus, that were removed from the Clitellarinae possess ventral hooks. These curious structures may represent a clinging device for living in fast flowing water. Stratiomys larvae lack these structures but they are present on larvae of Odontomyia. It is possible that the hooks have evolved twice but it seems more likely that the genera are more closely related than they were previously thought to be.

Larvae of Nemotelus pose a special problem. In addition to lacking the ventral hooks, the orifice of the spiracular chamber is on the dorsal surface of the last abdominal segment and possesses a coronet of hydrofuge setae as contrasted with the terrestrial larvae which lack this feature and as contrasted with other aquatic and semi-aquatic larvae

which also have the chamber at the apex but possess a coronet of hydrofuge setae.

This combination of characters is quite unique and may provide the basis for elevating the genus to subfamily status, but before this can be done an exhaustive study of the adults would have to be undertaken. For the present, I include <u>Nemotelus</u> in the Stratiomyinae.

VIII. KEYS AND DESCRIPTIONS

Key to Suborders, Divisions and Principal Families of Brachycera-Orthorrhapha Based on Larval Characters

1. Head complete, or the posterior portion with deep longitudinal incisions; mandibles capable of horizontal movement; body consisting of thirteen segments in addition to head; with nine pairs of spiracles .... Suborder NEMATOCERA

- Head incomplete, frontal region not strongly arched; mandibles capable of vertical movement; body comprising fewer than thirteen segments and only exceptionally with as many as nine pairs of spiracles .... Suborder BRACHYCERA 2

2. Free cephaloskeleton present; head very poorly developed, completely unsclerotized dorsally; antennae poorly developed or absent, when present situated on a membranous surface; mandibles short and hook-like, usually capable of protrusion much beyond the poorly developed maxillae; maxillary palpi rarely visible .... Division CYCLORRHAPHA

- No free cephaloskeleton within the head capsule, the exoskeleton of the head at least dorsally indicated; antennae well developed, situated on the upper surface of the lateral lobe or on the slightly arched, sclerotized frontal plate; mandibles normally sickle-shaped, not protruding much beyond apices of the well developed maxillae, often much shorter, maxillary palpi distinct .... Division ORTHORRHAPHA 3

3. Posterior spiracles situated within a terminal or subterminal cleft or chamber, usually concealed, or with a terminal breathing tube; pupa free or enclosed in last larval skin 4

- Posterior spiracles visible, situated on apical, penultimate or antepenultimate segment, body not shagreened or visibly striated; pupa free 5

4. Body 12 segmented, cylindrical, not shagreened, usually longitudinally striated, abdomen with a girdle of pseudopods on each segment; head retractile; spiracular fissure vertical .... TABANIDAE

   Body 11 segmented, bristly, surface finely shagreened, without pseudopods; head not retractile; spiracular fissure transverse, sometimes rather small; peripneustic or amphipneustic .... STRATIOMYIDAE

5. Posterior spiracles situated on penultimate or antepenultimate segment..................................... THEREVIDAE

SCENOPINIDAE

MYDAIDAE

ASILIDAE

BOMBYLIIDAE

- Posterior spiracles situated on apical segment 6

6. Last abdominal segment obliquely truncate and with projecting processes; projecting portion of head and the flattened apical plate of last abdominal segment heavily sclerotized the former cone-shaped .... XYLOPHAGIDAE

(including Rhachiceridae and Coenomyidae)

- Last abdominal segment lacking projecting processes; projecting portion of head not pointed cone-shaped; last abdominal segment without a heavily sclerotized flattened terminal plate .... NEMESTRINIDAE

EMPIDIDAE

DOLICHOPODIDAE

RHAGIONIDAE

ACROCERIDAE

Family Stratiomyidae

In addition to the characters given in the key to families, stratiomyid larvae may be readily distinguished from other dipterous larvae (except for psychodid larvae) by the presence of calcium carbonate deposits* on the integument.

Family Diagnosis. - Head elongate and narrow except for ocular prominences; not retractile; antennae usually located antero-laterally, but varying among species; setae on dorsum of head variable; body 11 segmented; prothoracic segment with functional spiracles, that segment wider than the head; segments posterior to prothorax either parallel with the lateral margins of the prothorax or tapering in a posterior direction from the second abdominal segment as in <u>Stratiomys</u> (Fig. 106); posterior spiracles located in a transverse cleft on last abdominal segment; with or without a fringe of hydrofuge setae; pseudopods lacking, but strong curved hooks may be present on venter of penultimate and/or antepenultimate segment.

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* See under Materials and Methods

Key to Larvae of the Subfamilies of Stratiomyidae

of America North of Mexico

1. Last abdominal segment with a coronet of plumose or pinnate setae at the apex or, on dorsum; body attenuate; .... Stratiomyinae

- Last abdominal segment lacking a coronet of plumose or pinnate setae; body parallel-sided; 2

2. Pro- and mesothoracic segments with a smooth field on dorsum; anus bordered anteriorly by a transverse row of strong, posteriorly directed teeth .... Solvinae

- Pro- and mesothoracic segments with normal shagreened pattern on dorsum; anus not bordered anteriorly by teeth 3

3. Mouthparts highly sclerotized and foreshortened, mandibles well developed, no setae or bristles present on mouthparts (Fig.16); recorded from San Francisco area, only .... Chiromyzinae

- Mouthparts with a different combination of characters than those listed above; occurring in San Francisco area or elsewhere 4

4. Dorsal row of transverse setae surrounded by smaller setae; mouthparts as in Fig. 17; uniformly colored larvae .... Beridinae

- Dorsal row of transverse setae not surrounded by smaller setae; mouthparts different than above; larvae uniformly colored or with a pattern.. 5

5. Larva with a well developed labium (Fig. 20); restricted to southwestern United States .... Adoxomyiinae

- Larva lacking a well developed labium; occurring in southwestern United States and elsewhere 6

6. Small larva, under 10 mm. in length; mouthparts similar to those of Beridinae (Fig.19); found under bark of trees .... Pachygasterinae

- Larva over 10 mm. in length; mouthparts lacking sclerotized areas 7

7. Mouthparts simple, setae restricted to a linear patch on inner margin of mandibular-maxillary complex (Fig. 22); large, robust, color uniform .... Hermetiinae

- Mouthparts more elaborate, setae present on mandibular-maxillary complex, in addition to setae restricted to notch on inner margin of complex (Fig. 18); smaller, usually with a vittate pattern .... Sarginae

Subfamily Solvinae

This subfamily is represented in North America by the single genus Solva Walker. It is the most primitive group of the Stratiomyidae in that it shares at least one character of the adult stage with the corresponding stage of the generally more primitive Xylophagidae.

Subfamily Characters*

Mouthparts as in Fig. 15. Other characters as given in key to subfamilies.

Habitat of The Larvae

The few records available indicate that the larvae live under the bark of trees and in rotting logs.

Genus Solva Walker, 1860

Prior to this study the genus Solva was thought to be represented in North America by only one species, Solva pallipes (Loew). However, Curran (1934), Lindner (1938), and Hennig (1952) include the species of Xylomyia in Solva and I accept this arrangement. Thus the number of species is increased to six.

To my knowledge no larva has been described of any species originally included in Xylomyia, but probably the external appearance of such a larva is the same as that of Solva. If this assumption is correct then the larva which I have described as Solva sp. could well be

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* These characters are known to be valid only for the North American species. I have not seen larvae of the east Asian genus Nematoceropsis Pleske.

the larva of a New England species of Xylomyia.

Key to The Species of Solva Walker

1. Prothoracic segment of larva with a tubercle anterior to the spiracle giving a cleft appearance to margin (Fig. 11); apical abdominal segment with a transverse row of tubercles on dorsum .... pallipes

- Prothoracic segment of larva lacking cleft appearance of margin; no tubercles present on dorsum of apical abdominal segment .... sp.

Solva pallipes (Loew), 1863

(Figs. 9, 10, 11, 13, 14 and 15)

Description.- Mature larva.- Size: length 7 - 8 mm., mean 7.8 mm.; width 1.75 - 2.0 mm., mean 1.85 mm. Other characters as given in key to species.

Pupa (after Greene, 1926). - Very thin, shining, transparent, with a yellowish tinge. Antennal capsules large, pointing outward, faintly annulated to the tip; just posterior to the base of these are three faint ocellar punctures. Thorax slightly longer than wide, smooth; wing pads smooth, reaching to the apex of the third abdominal segment; thoracic spiracle situated on a small elevation; the spiracular entrance is golden yellow, sinuous, and contains a great number of short radiating slits. Abdomen cylindrical, composed of eight segments; first and last segment without any spines; segments 2 to 7 with a transverse, dorsal row of reddish-yellow spines just posterior to the middle of the segment; segments 1 to 7 have a spiracle on the antero-lateral surface; spiracle

small, golden yellow, slightly elevated; last segment rounded at apex and entirely smooth. Length, 6.0 mm.; diameter of thorax, 1.85 mm.; diameter of abdomen, 1.75 mm.

Biology. - Larvae have been collected from the following trees: Ulmus sp., Populus sp., Robinia sp. and Liriodendron tulipifera. The larvae seem to prefer trees on which the bark has become loosened. Malloch (1917) intimates that he found the larvae of Solva to be predaceous on the larvae of Euxesta, Lonchaea, and Heterominga. Greene (1926) states that the larvae may be predaceous but are usually scavengers.

As the larva of Solva matures it forms a pupa within the last larval skin as is the case with all stratiomyid larvae. However, before emergence occurs the puparium splits dorsally down the median line and the pupa forces itself about two thirds of the way out of the puparium and remains there until the adult emerges. The emergence of the pupa causes the head of the puparium to become loose and often completely separated as in the higher flies. Adults of Solva can be found on tree trunks in June, July and August.

Material Examined. - ILLINOIS: Rock Island, 5.IV.1932, C. O. Mohr, 2 larvae (I.N.H.S.); PENNSYLVANIA: Blain, 6.VIII.1955, F. Craighead, Lot. No. 55 11825, 6 larvae, 7 puparia from oak (U.S.N.M.); WISCONSIN: Madison, 7.1938, Dodge, 23 larvae, 6 puparia from under elm bark (O.S.U.).

Solva sp.

(Figs. 8, 12 and 26)

Description.- Mature larva.- Size: Length 13 mm., width 3.2 mm.

Other characters as given in key to species.

Biology. - No data are available for this species.

Material Examined. - MASSACHUSETTS: Amherst, 1945, M.E.S., 1 larva (M.S.C.).

Discussion. - I have seen only one specimen of this species. It is more robust than S. pallipes but very similar in general habitus. Interestingly, the six transverse setae on the dorsum of the abdominal segments of this species agree with the description of S. maculata of the Old World, the type species of the genus Solva.

Subfamily Chiromyzinae

Although the genus Altermetoponia Miller has been placed in this subfamily there is some doubt as to whether it should be left here or placed in a subfamily of its own as Hennig (1952) has done. Because of a scarcity of specimens in related genera within the subfamily it has been impossible to make a comparison of characters. Raff (1931) provides a vague description of the larva of Chiromyza australis Macquart, the only published information available on the larvae of this subfamily.

The subfamily is represented in North America by Altermetoponia rubriceps (Macquart), only.

Subfamily Characters

As given in key to subfamilies.

Habitat of the Larvae

The only species of Chiromyzinae for which habitat data are available is A. rubriceps.

Genus Altermetoponia Miller, 1945

(Figs. 16, 26, 34 and 35)

Description. - Mature larva. - Size: length 8.8 - 9.8 mm., mean 9.27 mm.; width 1.8 - 2.0 mm., mean 1.87 mm. Body segments yellow; head brown, darkest at apex.

Biology. - It is quite probable that this species will become of economic importance in the area around San Francisco, just as it is considered to be a pest in Australia where it causes extensive damage to

lawns. Other than that it lives in sod as a larva, nothing is known about its life history in North America.

Material Examined. - CALIFORNIA: San Francisco, Mission Park, 20.XI.1959, T.R. Haig, 35 larvae, 3 puparia (C.A.S.).

Subfamily Beridinae

Of the five genera which represent this subfamily in North America the larvae of only three genera are known (Allognosta, Dieuryneura and Exodontha). However, larvae of the two remaining genera are known from other geographical areas and I have included the descriptions of those species so that a more complete picture of the Beridinae could be presented.

Subfamily Characters

As given in the key to subfamilies.

Habitat of the Larvae

The larvae in this subfamily are terrestrial but may be associated with semi-aquatic environments. For example, Fuller (1934) found larvae of Actina in and on the carcass of a dead sheep, Johannsen (1922) reported larvae of Allognosta from decaying organic material and the larvae of Beris have been found in decaying leaves. In addition to being the center of their food source, the semi-aquatic medium facilitates movement and ingestion by these larvae.

Key to the Genera of the Larvae of the Subfamily Beridinae

1. Larva robust, greater than 10 mm. in length 2
- Larva smaller, less than 10 mm. in length 3
2. Venter of antepenultimate segment with sternal patch located at basal margin; integument dark brown .... Dieuryneura
- Venter of antepenultimate segment with sternal patch located medially; integument light .... Exodontha

3. Abdominal segments with lateral margin bilobed, the anterior lobe smaller than the posterior one .... Allognosta

- Abdominal segments with lateral margin smooth 4

4. Last abdominal segment broadly indented at distal end and fringed with fine setae .... Beris

- Last abdominal segment not indented at distal ends; fringe lacking. .... Actina

Genus Allognosta Osten Sacken, 1883

There are four species recognized in this genus but only the larva of Allognosta fuscitarsis (Say) has been reported (Johannsen, 1922).

Generic Characters

As given in the key to genera

Allognosta fuscitarsis (Say), 1823

(Figs. 32, 37, 38 and 39)

Description. - Mature larva. - Size: length 9.5 mm., width 3.5 mm. Prothoracic spiracle located in a distinct marginal notch. Other characters as given in key to genera.

Biology. - Little is known of the biology and life history of this species. Malloch's (1917) specimen was obtained from a woods near Urbana, Illinois, while Johannsen (1922) reported that his specimens were found in decaying organic matter.

Material Examined. - RHODE ISLAND: Kingston, 20.VIII.1942, H. Knutson, 1 early instar larva from glass of milk (MSC); NEW YORK:

Ithaca, C. Hamilton, 2 larvae, 1 puparium (C.U.), Ithaca, 2 early instar larvae collected with larvae of _Fannia_ sp. (C.U.); NORTH CAROLINA: Great Smoky Mountain National Park, 4.X.1951, J.S. Ayars, Acc. No.49768, 11 larvae (N.C.S.).

Genus _Actina_ Meigen, 1804

Only one species of this genus is known from North America, the immature stages of which have never been reported.

The characteristics that are given below are taken from a paper by Fuller (1934) in which she described the immature stages of an Australian species, _Actina incisuralis_ Macquart.

Generic Characters

As given in key to genera.

Actina incisuralis Macquart, 1847

(Figs. 41, 42, and 46)

Description. - Mature larva (?). - Size: length 9 mm. Color varying between greyish-brown and brown. "Head elongated, narrow and pointed. Body strongly constricted between the segments giving the larva a scalloped appearance along the sides. Dorso-laterally the integument between each abdominal segment, and between the third thoracic and first abdominal, is produced into a small papilla projecting outwards. The thoracic segments become broader passing from the head, whilst the abdominal segments are of uniform width and length, with the exception of the eighth, which is narrower and longer than the others, more flattened and produced into two blunt projections at the posterior corners". Setal

arrangement typical for family and subfamily.

Biology. - Fuller reported that larvae of this species "were found in abundance on the undersurface of a sheep carcass", and, "on the earth under masses of rotting grass". Larvae were also present in soil among the roots and stems of growing grasses. Pupae were obtained 7-8 months after the larvae were collected.

Material Examined. - No larvae of this species were examined.

Genus Beris Latreille, 1802

Three species are recorded for this genus in North America but the larvae or pupae have never been reported. The larval stages of a few European species of Beris have been described (Lenz, 1923). The larva described below was loaned to me by W. Hennig.

Generic Characters

As given in key to genera.

Beris vallata Forster, 1771
(Figs. 24, 27 and 29)

Description. - Mature larva (?). - Size: length 7-8 mm., width 2 mm. Head and body segments yellow; body of larva extremely flattened dorso-ventrally; prothoracic spiracle elevated but relatively inconspicuous; body segments from 2nd thoracic to 7th abdominal with a distinct papilla at intersegmental fold.

Biology. - Nothing is known about the biology of the North American species. Lenz (1923) reports that larvae of Beris vallata and two other species of this genus were found under the bark of a fallen

tree which was lying in a marshy area, between fallen leaves (presumably wet leaves) and at the margins of springs.

Material Examined. - Two larvae borrowed from the Deutsches Entomologisches Institut, no collecting data.

Genus Exodontha Rondani, 1856

According to James (1960 A), two species occur in North America, but larvae and pupae of only Exodontha luteipes (Williston) have been found.

Generic Characters

As given in key to genera.

Exodontha luteipes (Williston), 1885

(Figs. 30, 31 and 36)

Description. - Mature larva. - Size: length 11.7 - 15+ mm., mean 13.23 mm.; width 3.8 - 4.5 mm., mean 4.77 mm. Head and body segments yellow.

Biology. - Larvae of this species were found in moist rotting wood under large boulders on a mountainside clearing at an elevation of approximately 6,000 feet. Adults emerged on June 27, 1960 in the laboratory.

Material Examined. - ALBERTA: Banff National Park, Mt. Ishbel, 13.VI.1960, Ball, Madge and McFadden, 1 larva, 4 puparia (M.W.M.).

Genus Dieuryneura James, 1937

The single species listed by James (1960 A) in this genus is

restricted to the southwestern United States.

Generic Characters

As given in key to genera.

Dieuryneura obscura (Coquillett), 1902

(Figs. 17, 25, 28 and 33)

Description. - Mature larva. - Size: length 14.9 mm., width 4.0 - 4.3 mm., mean 4.1 mm. Head and body segments dark brown.

Biology. - Larvae of this species were collected from a decaying sotol plant stem (*Dasylirion* sp.).

Material Examined: TEXAS: 12 miles N. Presidio, 18.IV.1952, 52-6319-Presidio-3119-L, 1 larva, 11 puparia (U.S.N.M.).

Discussion. - Larvae of this species are similar to the larvae of *Exodontha luteipes* but can be differentiated easily on the basis of the key character, as well as size and coloration.

Subfamily Sarginae

Of the six genera listed for this subfamily by James (1960 A) larvae have been described for the following three genera only: <u>Sargus</u>, <u>Ptecticus</u> and <u>Microchrysa</u>.

The keys presented to the genera of this subfamily will work for mature larvae only, but where earlier instars are known descriptions of these forms are included.

Subfamily Characters

As given in key to subfamilies.

Habitat of the Larvae

Larvae of the Sarginae are terrestrial scavengers. They have been collected from various types of manures, rotting vegetation, especially garden refuse and from other types of decaying organic matter.

Key to the Genera of the Larvae of the Subfamily Sarginae

1. Venter of sixth abdominal segment with sternal patch extending almost the length of that segment; venter of fifth abdominal segment with a smaller sternal patch (Fig. 51).... <u>Ptecticus</u>

\- Venter of sixth abdominal segment with shorter sternal patch; sternal patch lacking on venter of fifth abdominal segment 2

2. Lateral margin of head lacking a protruding tubercle; no constriction of head posterior to eye prominence........ <u>Sargus</u> (in part) (<u>s.st.</u>)

\- Lateral margin of head with a protruding tubercle; head constricted posterior to tubercle 3

3. Eye prominence anterior to protruding lateral tubercle ....
.... Sargus (Pedicellina)

- Eye prominence on protruding lateral tubercle 4

4. Width of head of larva at tubercle not more than 0.5 mm..........
.... Microchrysa

- Width of head of larva at tubercle 0.8 - 1.0 mm.................
.... Sargus (in part) (s.st.)

Genus Sargus Fabricius, 1798

Larvae of this genus are almost impossible to identify to species unless they are fully mature specimens. Earlier instars lack the characteristic patterns of the species and the head capsule apparently varies from instar to instar.

Generic Characters

As given in key to genera.

Key to Subgenera of Sargus Fabricius

1. Dorsolateral margin of segments 1 - 10 with a series of large, dark, plaques arranged in a circular pattern; segments 1 - 3 with a transverse band of these plaques connecting the two lateral circles; five vittae on dorsum, the mesal vitta much broader than the others................................ Pedicellina

- Dorsolateral margin of segments 1 - 10 lacking the large dark plaques or if present, not arranged in any specific pattern; vittae if present numbering 3 or 6 .... Sargus

Subgenus Pedicellina James, 1952

Sargus (Pedicellina) lucens Loew, 1866

(Figs. 50, 57 and 62)

Description. - Mature larva. - Size: length 9.2 - 11 mm., mean 10.1 mm.; width 2.5 - 3.3 mm., mean 2.85 mm. Other characters as given in key to subgenera.

Biology. - Larvae of this species have been collected from leaf axils of cattails only where axils were above the water line.

Material Examined. - NEW YORK: Ithaca, 8.IV.1921, P.W. Claasen and O.A. Johannsen, 5 larvae, 15 puparia collected from leaf axils of cattails (above water line)(C.U.); Ithaca, July (?), 2 larvae from leaf axils of cattails (above water line)(C.U.).

Subgenus Sargus Fabricius, 1798

Key to the Species of the Subgenus Sargus

1. Body segments lacking vittae; prothoracic spiracle on stalk-like structure .... elegans
- Body segments with alternating dark and light vittae; prothoracic spiracle sessile 2
2. Dorsal surface of body segments with three dark vittae ... decorus
- Dorsal surface of body segments with six dark vittae 3
3. Median light band between inner two dark vittae parallel sided ... . bipunctatus
- Median light band between inner two vittae geniculate; each of inner pair of setae located in a dark patch in median light band .... viridis

Sargus elegans Loew, 1866

(Figs. 53, 54 and 61)

Description. - Mature larva. - Size: length 7.8 mm., width 2.4 mm.; head not restricted posterior to eye prominence, ratio of width of head at eye prominence to width at neck 1.0. Other characters as given in keys to genera and subgenera.

Instar No.? - Size: length 4.5 - 5.2 mm., mean 4.96 mm.; width 1.4 - 2.0 mm., mean 1.68 mm.; differ from mature larvae in that they lack the stalked prothoracic spiracle.

Biology. - Larvae of this species have only been collected from under horse manure.

Material Examined. - ONTARIO: Marmora, 19.VI.1952, J.R. Vockeroth, 2 puparia, larvae collected from under horse dung in woods (C.N.C.); VIRGINA: Alexandria, 24.VI.1951, W.W. Wirth, 15 larvae (early instar) from under horse dung (U.S.N.M.).

Sargus decorus Say, 1824

(Figs. 56, 59 and 60)

Description. - Mature larva. - Size: length 4.0 - 4.2 mm., mean 4.1 mm.; width 3.0 - 3.3 mm., mean 3.13 mm.; width of head at eye prominence 0.81 - 0.94 mm., mean 0.87 mm.; width of head at neck 0.48 - 0.59 mm., mean 0.52 mm.; mean ratio of width of head at eye prominence to width at neck 1.67. Other characters as given in key to species.

Biology. - Larvae of this species have been collected from rotting leaves and cow manure.

Material Examined. - SASKATCHEWAN: Saskatoon, 1.VIII.1949,

A.R. Brooks, 14 puparia from cow manure (C.N.C.); WASHINGTON: Seattle, 15.IX.1942, Lot No. 42-11571, det. by C.T. Greene, 4 larvae, 5 puparia from rotting leaves (U.S.N.M.).

Sargus bipunctatus Scopoli, 1763

(Figs. 49, 55 and 58)

Description. - Mature larva. - Size: length 7.0 - 13.6 mm., mean 10.98 mm.; width 4.0 - 4.5 mm., mean 4.2 mm., width of head at eye prominence 0.98 - 1.03 mm., mean 1.01 mm.; width of head at neck 0.64 - 0.66 mm., mean 0.65 mm.; mean ratio of width of head at eye prominence to width at neck 1.54. Other characters as given in key to species.

Biology. - Larvae of this species have been collected from rabbit droppings.

Material Examined. - WASHINGTON: Puyallup, 18.VIII.1948, G. Batchelor, 6 larvae, 6 puparia from rabbit manure (W.S.U.).

Sargus viridis Say, 1823

Description. - Mature larva. - Size: length 9 mm., width 3 mm. Other characters as given in key to species.

Instar No. ? - Size: length 6.5 mm., width 2.4 mm. Differs from mature larva in that it lacks the vittae.

Biology. - Larvae of this species have been collected from cow manure. Malloch (1917) reported the larvae as being very sluggish.

Material Examined. - MARYLAND: Braddock Heights, 1.X.1921, A.N. Caudell Collection, 1 larva (early instar) (U.S.N.M.).

Discussion. - All data regarding description of the mature larva and notes on its biology have been taken from Malloch.

Sargus cuprarius (Linnaeus), 1758

(Figs. 18, 63, 64 and 65)

Description. - Instar No. ?-Size: length 6.5 - 7.4 mm., mean 7.04 mm.; width 1.7 - 2.0 mm., mean 1.84 mm. Similar to *S. decorus* in this stage but much smaller.

Biology. - Larvae of this species have been collected from under cow manure.

Material Examined. - NEBRASKA: Dunbar, 13.IX.1950, W.W. Wirth, 39 larvae from cow manure (early instars) (U.S.N.M.).

Genus *Ptecticus* Loew, 1855

Of the two species listed by James (1960) for this genus only the larvae of *P. trivittatus* Say have been collected.

Ptecticus trivittatus (Say), 1829

(Figs. 44, 48, 51 and 52)

Description. - Mature larva. - Size: length 11.2 - 13.2 mm., mean 12.68 mm.; width 3.5 - 3.9 mm., mean 3.76 mm.; apical segment with two setae at each corner of spiracular opening; no anal spines present; other characters as given in key to species.

Antepenultimate instar. - Size: length 12.2 - 15.1 mm., mean 13.67 mm.; width 3.0 - 4.5 mm., mean 3.67 mm.; larvae testaceous, no visible pattern; body setae short, partially hidden by fine pubescence which covers body; anal spines present.

Biology. - Larvae of this species have been collected from a corn compost pile, from decaying tomatoes, decaying garbage, rotting paper, decaying fruit and from watermelon rinds. Larvae have also been collected from a fungus (*Laetiporus speciosus*).

Material Examined. - GEORGIA: Silver Lake 7 larvae (C.U.); ILLINOIS: Urbana 14 larvae (I.N.H.S.); MARYLAND: Cabin John Bridge 11 larvae (U.S.N.M.); NORTH CAROLINA: Faison 1 larva (N.C.S.), Faison 5 larvae (N.C.S.), McCulley's 3 larvae (N.C.S.): OHIO: O.A.E.S. 17 larvae (O.S.U.), Wooster 2 larvae (O.S.U.): TENNESEE: University of Tennesee Farm 13 larvae (U.S.N.M.); VIRGINIA: Falls Church 5 larvae, 6 puparia (U.S.N.M.). (See appendix B for detailed collection data.)

Genus Microchrysa Loew, 1855

James (1960 A) lists two species for this genus but only the larvae of Microchrysa polita (Linnaeus) have been collected to date.

Microchrysa polita (Linnaeus), 1758

(Figs. 43, 45 and 47)

Description. - Mature larva. - Size: length 5.2 - 7.1 mm., mean 6.68 mm.; width 1.6 - 2.0 mm., mean 1.84 mm.; width of head at eye prominence 0.45 - 0.50 mm., mean 0.47 mm.; width of head at neck 0.32 - 0.42 mm., mean 0.36 mm.; mean ratio of width of head at eye prominence to width at neck 1.32; venter of sixth abdominal segment with the seta on each side of the sternal patch reduced; anal spines lacking.

Biology. - Larvae of this species have been collected from cow manure and from decaying vegetation.

Material Examined. - COLORADO: Woodland Park 3 larvae (U.C.); MASSACHUSETTS: Amherst 2 puparia (M.S.C.); NEW YORK: Ithaca 4 larvae (C.U.); Ithaca 5 larvae, 3 puparia (C.U.), Ithaca 9 larvae (C.U.); NORTH CAROLINA: Rowan County 1 larva (N.C.S.). (See appendix B for detailed collection data.)

Subfamily Hermetiinae

Composed of the single genus Hermetia, this subfamily is represented in North America by eight species. Seven of them appear to be restricted to the southwestern United States. One species, Hermetia illucens (Linnaeus), has been recorded from as far north and east as Maryland and Delaware.

Subfamily Characters

As given in key to subfamilies.

Habitat of the Larvae

Hermetiine larvae are terrestrial scavengers. They have been reported from excrement (mammal and avian), decaying vegetable matter, wax in beehives and from a cadaver (Dunn, 1916). H. illucens (L.) has been involved in human enteric myiasis (James, 1947).

Key to the Species of Hermetia Latreille

1. Lateral and transverse setae (dorsal and ventral) very prominent; body segments with dense yellow pubescence especially on apical segment and on lateral margins .... illucens

\- Lateral and transverse setae not prominent; dense yellow pubescence lacking or if present on dorsum of thorax, then divided into two patches by a bare median line 2

2. Postero-ventral region of head with coarse yellow pubescence; two setae in prothoracic leg group .... sp.

\- Bib on venter of head lacking (Fig. 109); more than two setae in prothoracic leg group 3

3. Labrum barely extending beyond ocular lobes; point not drawn out, blunt appearance .... <u>concinna</u>

- Labrum extending beyond ocular lobes, end portion drawn out into a tapering point .... <u>aurata</u>

Genus <u>Hermetia</u> Latreille, 1804

I have seen larvae or puparia of four species of this genus, one of which I have not been able to identify.

<u>Hermetia illucens</u> (Linnaeus), 1758

(Figs. 22, 66, 76 and 80)

Description. - Mature larva. - Size: length 14.5 - 21.5 mm., mean 18.6 mm.; width 4.8 - 6.5 mm., mean 5.8 mm. Head and body segments reddish-brown; spiracles present on lateral margin of segments 3-10, accompanied by a small papilla on segments 2-5; anus not armed with spines; no transverse series of short spines.

Penultimate Instar. - Size: length 19.0 - 25.5 mm., mean 18.6 mm.; width 4.0 - 5.5 mm., mean 4.8 mm. Body segments whitish to creamy yellow, head and prothoracic spiracles almost black; anus armed with spines; all abdominal segments with a transverse series of darkly pigmented spines on venter near anterior margin.

Biology. - The larvae of <u>Hermetia illucens</u> are terrestrial scavengers. They have been reported from decaying vegetation, from privies and from various types of animal excrement. Furman, Young and Catts (1959) have shown that large numbers of larvae of <u>H. illucens</u> will prevent development of larvae of the housefly <u>Musca domestica</u> (Linnaeus) in poultry manure.

Copello (1926) stated that adults emerge from spring until early fall but this is probably not true for individuals in North America. Here there is but a single generation a year which probably emerges in the spring after a winter of dormancy. Copello also mentions that mating takes place during flight and later the females oviposit at the edge of decaying organic material. The eggs hatch in a few days but larval development is very slow. In addition he reports larvae of H. illucens from weak beehives.

Material Examined. - ARKANSAS: Fayetteville (3)*; CALIFORNIA: Rosario Cirio (12); DELAWARE: Magnolia (10), Primehook Neck (8), Thompsonville (1); FLORIDA: Coll. No. 1884 U.S.N.M. (5-1 pupa); GEORGIA: Bissel (1), Camp Stewart (39-2 cast skins); LOUISIANA: Baton Rouge (13-1 cast skin); MARYLAND: Beltsville (4); MISSOURI: St. Louis (4); NEW MEXICO: Roswell (7); NORTH CAROLINA: Clay County (5), Clayton County (6), Faison (9), Fuguay (5), Long Beach (1), Onslow County (2), Raleigh (16), Rockingham (4); SOUTH CAROLINA: Clemson (33), Six Mile (1); TENNESEE: Knoxville (1 pupal case); WASHINGTON: Everett (10).

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* unless explained the number in brackets represents the number of larvae examined - detailed notes in Appendix B.

Hermetia concinna Williston, 1900

(Figs. 67, 70 and 73)

Description. - Puparium. - Size: length 17.3 mm., width 4.8 mm. Head and body segments testaceous; no spines present in transverse series on any segments.

Biology. - The puparium studied was taken from decayed sotol

(*Dasylirion* sp.). No other data are available.

Material Examined. - ARIZONA: Sierita Mountains, 30 miles southwest of Tucson, 27.XI.1913, E.A. Schwarz, 1 larva, 1 puparium (U.S.N.M.).

Hermetia sp.

(Figs. 69, 71 and 77)

Description. - Mature larva. - Size: length 17.5 mm., width 5.5 mm. Head and body segments orangy-yellow, head more darkly pigmented at distal end; eye spots not distinct; transverse row of small spines present on segments 1-7 near anterior margin.

Biology. - Same as noted for *H. concinna*.

Material Examined. - Three larvae with same data as for *H. concinna*.

Discussion. - There may be some doubt as to the validity of this species because the specimens used to describe it were found with those of *H. concinna*.

Hermetia aurata Bellardi, 1859

(Figs. 68, 72 and 74)

Description. - Puparium. - Size: length 17.8 - 22.3 mm., mean 20.05 mm.; width 5.1 - 6.0 mm., mean 5.55 mm. Other characters as given in key to species.

Biology. - Larvae have been collected from prickly pear (*Opuntia occidentalis*).

Material Examined. - CALIFORNIA: San Dimas Canyon, Pomona, Los Angeles County, 4.XII.1960. A.D.M. 72, Ryckman and Olsen, two puparia (W.S.U.).

Subfamily Adoxomyiinae

This subfamily includes three genera, Adoxomyia, Cyphomyia and Dicyphoma. The range of these three genera extends from South America to and including the southwestern region of the United States. Fourteen species have been collected from this area as adults but the genus Adoxomyia which contains eleven of the fourteen species is completely unknown from the larval stage.

Subfamily Characters

As given in key to subfamilies.

Habitat of the Larvae

All specimens collected to date have been taken from decaying or wounded cactus. Larvae of an unknown species of Cyphomyia have been reported as occurring under the bark of cedar logs in Honduras.

Key to the Genera of the Larvae of the Subfamily Adoxomyiinae

1. Head without a distinct notch posterior to eye prominence; outside seta in transverse series on venter of sixth abdominal segment shorter than next seta toward sternal patch .... Adoxomyia

- Head with a distinct notch posterior to eye prominence; outside seta in transverse series on venter of sixth abdominal segment approximately the same size as the next seta towards the sternal patch 2

2. Notch posterior to eye prominence almost completely enclosed,

giving appearance of hole through lateral margin of head .... *Cyphomyia*

- Notch posterior to eye prominence open; no indication of a hole through the lateral margin of the head .... *Dicyphoma*

Genus *Cyphomyia* Wiedemann, 1819

James (1960 A) recognizes two species in this genus, but the larva of only *Cyphomyia bicarinata* Williston is known. Because the larvae are an early instar, pin-mounted, and in poor condition, I have substituted the description of a neotropical species, *Cyphomyia pilosissima* Gerstaecker, for that of *C. bicarinata*. Generic characters as given in key to genera.

Cyphomyia pilosissima Gerstaecker, 1857

(Figs. 84, 85 and 86)

Description. - Mature larva. - Size: length 21 mm., width 5 mm.; dorsally the anterior and posterior margins of the thoracic and of the first seven abdominal segments somewhat elevated with low transverse ridges occupying approximately the anterior and posterior fourth or fifth of the segment; ventrally these areas are only slightly elevated.

Biology. - Larvae of *C. bicarinata* as well as larvae of *C. pilosissima* have been taken from wounds in cacti, *C. bicarinata* from prickley pear (*Opuntia* sp.) and *C. pilosissima* from maguey (*Agave* sp.). No other data are available.

Material Examined. - MEXICO: Tlaxcala, K66 (Puebla Hwy.), 12.1.1956, W.E. Snow, 1 larva from base of maguey (W.S.U.).

Discussion. - Whether or not the mature larvae of C. bicarinata possess the type of notch described for this species and consequently for the genus will not be known until more specimens are collected. However, because larvae of this genus are only rarely collected I felt it would be better to have the description of a mature larva rather than an immature one.

Genus Dicyphoma James, 1937

Only one species, Dicyphoma schaefferi (Coquillett) occurs in the Nearctic area. It is restricted to the southwestern states where it has been taken from wounded and decaying cactus.

Generic Characters

As given in key to genera.

Dicyphoma schaefferi (Coquillett), 1904

(Figs. 79, 82 and 83)

Description. - Mature larva. - Size: length 14.0 - 15.8 mm., mean 15.2 mm.; width 3.6 - 4.1 mm., mean 3.87 mm.

Biology. - Larvae have been collected from Opuntia (Platyopuntia) and Myrtillocactus geometrizans in Mexico.

Material Examined. - MEXICO: 54 miles N. San Luis Potosi, S.L.P., 4.VIII.1960, Ryckman, Ryckman and Christianson, ADM 61, 2 larvae (W.S.U.); 8 miles S. Aguascalientes, 19.VI.1960, ADM 46, Ryckman, Ryckman and Christianson, 1 larva (W.S.U.).

Discussion. - Except for the key characters there appears to be

little difference between the larva of D. schaefferi and that of C. pilosissima.

Genus Adoxomyia Kertész, 1907

James (1960 A) lists eleven species for this genus all of which except A. subulata are confined to the southwestern and western states.

Generic Characters

As given in key to genera.

Adoxomyia sp.

(Figs. 75, 78 and 81)

Description. - Mature larva. - Because the larvae of this species are from such a distant area (India) and are unknown, a description of them is not essential.

Biology. - Larvae of this species were collected from Kaempferia sp., a tuberous-rooted plant. Larvae of a North American species, A. claripennis have been collected from a decaying cactus.

Material Examined. - INDIA: Calcutta, 26.V.1955, HO-19477, Lot No. 55-11257, 10 larvae, 5 puparia (U.S.N.M.); ARIZONA: Mission Tucson, Pima County, 27.XII.1951, Ryckman, Ames and Arakawa, 2 puparia (U.S.N.M.).

Discussion. - Unfortunately all the larvae of A. claripennis collected by Ryckman, et al. were allowed to reach the adult stage. The two puparia seen by me both lacked the head capsule making a description an impossibility at this time. However, I had in my possession a vial which contained larvae of an unknown species of Adoxomyia from India. The generic characters given in the key are based on this material.

Subfamily Pachygasterinae

In their recent revision of this subfamily Kraft and Cook (1961) have presented an up-to-date résumé of the biology and taxonomy of both adults and larvae. Keys were presented for distinguishing between larvae in each of the five genera and within the two genera Zabrachia and Eupachygaster.

I have found variation in the measurements given by Kraft and Cook as compared with those taken by myself. In one species, Eupachygaster henshawi Malloch, this variation is one millimeter and represents an error of 25%. In spite of this, I do not believe that these mensural variations represent specific differences but, rather, indicate a small sample which may have been taken from a limited geographic area. I have placed the measurements given by Kraft and Cook in brackets and have presented my own measurements including range and mean.

Subfamily Characters

As given in key to subfamilies.

Habitat of the Larvae

Pachygasterine larvae have been found under the bark of both deciduous and coniferous trees. Oviposition usually occurs on wounded or dead trees but in either case there must be enough moisture present in the host for the larvae to be able to obtain nourishment. Host trees mentioned by Kraft and Cook are: apple, quaking aspen, dwarf elm, American elm, cottonwood, hickory, white pine, Douglas fir, Engelmann

spruce and shore pine.

The larvae are gregarious (I have collected approximately 100 larvae beneath the bark of a single log), extremely slow moving and feed on the sap or microorganisms that occur in the moist areas beneath the bark. Malloch (1917) has suggested that pachygasterine larvae are predatory on other insect larvae but this has not been observed.

Key to the Genera of the Larvae of the Subfamily Pachygasterinae
(modified after Kraft and Cook, 1961)

1. Teeth along anal opening prominent; setae on margin of last segment short, no longer than one-fourth width of last segment (Fig. 142) 2
- No prominent teeth along anal opening; setae on margin of last segment long, at least one-third as long as width of last segment (Fig. 141) 3
2. Midventral line of abdominal segment six with a round sternal patch, located anterior to transverse row of setae; eight or more pairs of conspicuous plaques along dorsal midline of last segment .... Berkshiria
- Sternal patch on midventral line of abdominal segment six oval, located between setae of transverse row; no more than three or four pairs of conspicuous plaques along dorsal midline of last segment .... Neopachygaster
3. Each thoracic leg group with two setae (Fig. 141).... Eupachygaster
- Each thoracic leg group with three setae (Fig. 143) 4
4. Abdominal segments one to seven each with eighteen setae (Fig. 149) .... Pachygaster

- Abdominal segments one to seven each with twenty setae (Fig. 143).. .... _Zabrachia_

Genus _Berkshiria_ Johnson, 1914

This genus contains the single species _Berkshiria_ _albistylum_, the larva of which has been collected from beneath the bark of deciduous trees only. As Kraft and Cook have pointed out, it resembles _Neopachygaster_ but can be readily distinguished on the basis of the form of the sternal patch.

Generic Characters

As given in key to genera.

Berkshiria _albistylum_ Johnson, 1914

(Fig. 142)

Description. - Mature larva. - Size: length (5.0 - 7.2 mm.) 5.0 - 5.9 mm., mean 5.3 mm.; width (1.6 - 2.0 mm.) 2.0 - 2.4 mm., mean 2.2 mm.

Biology. - Larvae of _Berkshiria_ _albistylum_ have been collected from under the bark of poplar (_Populus_ _deltoides_) and elm (_Ulmus_ _pumila_). Cook (1953) reported that the larvae have at least four instars which apparently do not form distinct size groups. He also mentioned that the pupal period lasted from 8 to 10 days and that the adults did not live for more than 5 days in the laboratory.

Material Examined. - 8 larvae from the Ohio State University collection with the following data: 5.12.1942, under bark of dead poplar.

Genus Zabrachia Coquillett, 1901

Of the eleven species listed for this genus by Kraft and Cook the larvae of only two species have been found. Both species were taken from beneath the bark of coniferous trees.

Generic Characters

As given in key to genera.

Key to Species of Zabrachia Coquillett, 1901

(after Kraft and Cook, 1961)

1. Ventral surface of abdominal segment six with eighteen large plaques .... politum
- Ventral surface of abdominal segment six with sixteen large plaques .... plicatum

Zabrachia politum Coquillett, 1901

(Fig. 146)

Description. - Mature larva. - Size: length (4.3 mm.); width (1.0 mm.); other characters as given in key to species.

Biology. - No data are available for this species.

Material Examined. - No larvae of this species were examined.

Zabrachia plicatum Kraft and Cook, 1961

(Fig. 143)

Description. - Mature larva. - Size: length 4.0 - 5.0 mm., mean 4.7 mm.; width 0.7 - 1.0 mm., mean 0.5 mm.; other characters given in key to species.

Biology. - Larvae have been collected from beneath the bark of Pinus contorta, P. ponderosa, Picea engelmanni, and Pseudotsuga mucronata.

Material Examined. - NORTH CAROLINA: Raleigh, 1941-1942, 9 larvae from fallen pine (N.C.S.).

Discussion. - In keying out this species I found it necessary to slide mount the integument in order to be sure of the number of plaques on segment six.

Genus Neopachygaster Austen, 1901

Kraft and Cook recognize four species in this genus. The larvae have been collected from both coniferous and deciduous trees.

Generic Characters

As given in key to genera.

Key to Species of Neopachygaster Austen, 1901

Kraft and Cook were unable to differentiate between the larvae of the species in this genus. Because of a lack of material I am also unable to contribute towards the identification of these species.

Neopachygaster occidentalis Kraft and Cook, 1961

(Fig. 148)

Description. - Larva. - Size: length 5.58 mm., width 1.69 mm. Tufts of setae of thoracic leg group with two inner setae of equal length, outer seta much shorter; otherwise indistinguishable from other larvae of this genus.

Biology. - Larvae were taken from under bark of Pinus ponderosa.

Material Examined. - No larvae of this species were examined.

Discussion. - All data presented for this species are taken directly from Kraft and Cook.

<u>Neopachygaster</u> <u>maculicornis</u> (Hine), 1902

(Figs. 19 and 147)

Description. - Mature larva. - Size: length (5.50 - 6.00 mm.) 6.0 - 6.5 mm., mean 6.17 mm.; width (1.40 - 1.50 mm.) 1.1 - 1.5 mm., mean 1.27 mm. Tufts of setae in thoracic leg group same as in <u>N</u>. <u>occidentalis</u>.

Biology. - Larvae have been collected by me from beneath the bark of a fallen poplar log (<u>Populus</u> sp.).

Material Examined. - ALBERTA: Medicine Hat, South Saskatchewan River, 7.VI.1960, Ball, Madge and McFadden, approximately 100 specimens of larvae and pupae (M.W.M.).

Discussion. - Adults of this species were reared from larvae by me. The measurements outside of the brackets were taken from the above mentioned specimens.

<u>Neopachygaster</u> <u>vitrea</u> Hull, 1930

Description. - According to Kraft and Cook the larva of this species is essentially the same as the larva of <u>N</u>. <u>maculicornis</u>.

Biology. - No data are available for this species.

Material Examined. - No larvae of this species were examined.

<u>Neopachygaster</u> <u>reniformis</u> Hull, 1942

Description. - Larvae. - Size: length 4.93 mm., width 1.45 mm. Very similar to larvae of <u>N</u>. <u>maculicornis</u>; tufts of thoracic leg setae

with the middle setae longest, inner seta next longest.

Biology. - No data are available for this species.

Material Examined. - No larvae of this species were examined.

Discussion. - All data presented for this species are taken directly from Kraft and Cook.

Genus Eupachygaster Kertész, 1911

Kraft and Cook recognize three species in this genus. The larvae have been collected from beneath the bark of both deciduous and coniferous trees.

Generic Characters

As given in key to genera.

Key to Species of Eupachygaster Kertész, 1911

(modified after Kraft and Cook, 1961)

1. Abdominal terga one to seven of approximately equal length with setae in transverse rows .... punctifer

- Setae in transverse rows with the outermost setae much shorter than the others in the row 2

2. Transverse row of six setae on abdominal sterna one to seven with all setae of approximately equal length .... henshawi

- Setae in transverse row with outermost setae much longer than others .... fusca

Eupachygaster punctifer Malloch, 1915

(Fig. 144)

Description. - Mature larva. - Size: length (6.2 mm.)

5.0 - 6.5 mm., means 5.8 mm.; width (1.7 mm.) 1.0 - 1.3 mm., mean 1.2 mm. Other characters as given in key to species.

Biology. - Larvae have been collected from under the bark of Carya, Populus and an unknown species of Pinus.

Material Examined. - DELAWARE: Sussex County, 6 larvae (U.D.); NORTH CAROLINA: Auburn, 1 larva (N.C.S.); West End, 12 larvae (N.C.S.). (See Appendix B for detailed collecting data.)

Eupachygaster fusca Kraft and Cook, 1961

(Fig. 141)

Description. - Mature larva. - Size: length (5.85 mm.) 4.2 - 7.0 mm., mean 6.0 mm.; width (.169 mm.) 0.9 - 1.7 mm., mean 1.5 mm. Other characters as given in key to species.

Biology. - The only recorded host for this species is willow (Salix sp.).

Material Examined. - NORTH CAROLINA: Rocky Mountain, 20 larvae; OHIO: Wooster, 5 larvae from under willow bark (N.C.S.). (See Appendix B for details on collecting data.)

Eupachygaster henshawi Malloch, 1917

(Fig. 145)

Description. - Mature larva. - Size: length (4.95 mm.) 5.7 - 6.9 mm., mean 6.5 mm.; width (1.44 mm.) 1.2 - 1.3 mm., mean 1.23 mm. Other characters as given in key to species.

Biology. - Larvae have been collected from under the bark of apple, elm and oak trees.

Material Examined. - NORTH CAROLINA: Auburn, VIII.I.1956, C.G.

Wright, 3 larvae from under bark of oak log (N.C.S.); Auburn, VIII.25.1956, C.G. Wright, 3 larvae from under bark of oak tree (N.C.S.).

Genus Pachygaster Meigen, 1803

Kraft and Cook list three species for this genus but larvae of only Pachygaster pulchra have been found.

Generic Characters

As given in key to genera.

Pachygaster pulchra Loew, 1863

(Fig. 149)

Description. - Larva. - Size: length 4.82 mm., width 0.94 mm. Narrow, dirty white, dorsal setae knobbed at tips; only nine pairs of setae on abdominal segments one to seven.

Biology. - Larvae of this species have been collected from tree crotch debris, tree holes, and hollow trees.

Material Examined. - No larvae of this species were examined.

Discussion. - All data presented for this species are taken directly from Kraft and Cook.

Subfamily Stratiomyinae

This subfamily is composed of the species of Stratiomyidae whose larvae are aquatic or semi-aquatic. The larvae vary in size from a few millimeters to 50 millimeters. One commonly finds larvae of this subfamily as representatives of this family in general collections of immature stages. This can be best explained by the fact that the aquatic species are more numerous and, therefore, easier to locate than the terrestrial species.

Subfamily Characters

As given in key to subfamilies.

Habitat of the Larvae

Stratiomyine larvae have been collected from almost every conceivable type of aquatic environment ranging from hot springs to fast-flowing brooks to ocean shores. Although larvae in the genus Stratiomys are at home in water depths of several feet, larvae in most of the remaining genera prefer to remain hidden in naturally occurring vegetation along the shore or margin of the water. Quite frequently these larvae are found in and under shore debris such as boards, logs, cans, cardboard boxes, weeds, and other types of decaying organic material.

Key to the Genera of the Larvae of the Subfamily Stratiomyinae

1. Seventh abdominal segment of larva with curved sclerotized hooks on venter (Fig. 123) 5
- Seventh abdominal segment without curved sclerotized hooks on venter 2
2. Antenna located at apex of ocular lobe (Fig. 127) 4

- Antenna not located at apex of ocular lobe 3

3. Spiracular cleft at apex of apical abdominal segment .... Caloparyphus (in part)

- Spiracular cleft on dorsum of apical abdominal segment...... Nemotelus

4. Integument of larva covered with minute, peltate scales (Fig. 91) .... Odontomyia, subgenus Catasina

- Integument lacking peltate scales .... Stratiomys

5. Sclerotized hooks present on venter of each of the first seven abdominal segments, those on the seventh larger than the others .... Euparyphus, subgenus Aochletus

- Sclerotized hooks absent from each of the first six segments; those on the seventh present.. 6

6. Hydrofuge setae on last abdominal segment attaching to two lobed structures on lower lip of spiracular cleft (Fig. 89); prothoracic spiracles located at anterior corner of that segment .... Myxosargus

- Hydrofuge setae attaching to straight edge of lower lip, lobed structures absent; prothoracic spiracle not located in anterior corner of prothrax 7

7. Antenna dorsal, not at apex of ocular lobe; prothoracic spiracles elevated or stalked 8

- Antenna at apex of ocular lobe; prothoracic spiracles neither elevated nor stalked... 9

8. Apical segment with lateral margin straight; distance from antenna to eye prominence greater than twice length of antenna .... Caloparyphus (in part)

- Lateral margin of apical segment tapering basally toward median line;

distance from antenna to eye prominence approximately equal to length of antenna ....*Euparyphus*, subgenus, *Euparyphus*

9. Venter of sixth and seventh abdominal segments with sclerotized hooks 10

- Venter of only seventh abdominal segment with sclerotized hooks .... *Odontomyia*, subgenus *Odontomyiina*

10. Body segments with broad dorsal vittae or body segments with fine white pubescence or multiple hooks .... *Odontomyia*, subgenus *Odontomyia*

- Without the above combination of characters .... *Hedriodiscus*

Genus *Nemotelus* Geoffroy, 1762

This genus contains 33 species in North America which are divided into two subgenera as follows: *Nemotelus* (12 species) and *Nemotelinus* (21 species). I have seen puparia of two species of *Nemotelinus* and larvae of a single species of *Nemotelus*.

Generic Characters

As given in key to genera.

Subgenus *Nemotelus* Geoffroy, 1762

The specimens representing this taxon consisted of three headless puparia in poor condition.

Nemotelus kansensis Adams, 1903

(Figs. 121 and 124)

Description. - Puparium. - Size: length 7.2 mm. (less head and

prothorax), width 2.6 mm.

Biology. - Larvae of this species were collected from a salt spring (probably from the margin).

Material Examined. - MISSOURI: Petersburg, 1.VI.1955, P.J. Spangler, 3 puparia (W.S.U.).

Discussion. - The pattern on the dorsum of the body segments and the arrangement and placement of setae both agree very closely with that of Nemotelus canadensis Loew.

Subgenus Nemotelinus Enderlein, 1936

Key to the Species of Nemotelinus Enderlein

1. Larva less than 4 mm. in length; dorsum of body segments lacking vittae and plaques .... centralis

- Larva 5 mm. or more in length; dorsum of body segments with vittae and plaques (Fig. 122) .... canadensis

Nemotelus centralis Hanson, 1958

(Figs. 101, 104 and 105)

Description. - Mature larva. - Size: 3.5 - 3.7 mm., mean 3.6 mm.; width 0.8 - 1.0 mm., mean 0.9 mm. Head light brown, body white; prothoracic spiracles dark.

Biology. - No data are available for this species.

Material Examined. - MICHIGAN: Cheboygan County, 17.VIII.1957, W.J. Hanson, three larvae, lab reared (K.U.).

Nemotelus canadensis Loew, 1863

(Figs. 122, 125 and 135)

Description. - Puparium. - Size: length 7.7 - 8.3 mm., mean 8.0 mm.; width 1.8 - 2.0 mm., mean 1.9 mm. Other characters as given in key to species.

Biology. - Larvae of this species have been collected from under cow manure and rotting vegetation at the edge of highly alkaline lakes (pH 8.6).

Material Examined. - ALBERTA: Chappice Lake, 18 miles N. Medicine Hat, 7.VI.1960, Ball, Madge and McFadden, 3 puparia (M.W.M.); Gooseberry Lake Provincial Park, 9 miles north of Consort, 5.VI.1960, Ball, Madge and McFadden, 8 puparia (M.W.M.).

Genus Stratiomys Geoffroy, 1762

This is one of the largest genera of soldier flies that occurs in North America. Of the twenty-one species listed by James (1960 A) I have seen associated larvae or puparia of seven species.

Generic Characters

As given in key to species.

Key to the Species of Stratiomys Geoffroy

Although associated puparia of seven species were available I was able to separate only one species (S. discaloides Curran) from the remaining six.

1. Length of last abdominal segment approximately two times the basal width of that segment .... discaloides

- Length of last abdominal segment greater than two times the basal width of that segment .... _adelpha_

badia

barbata

meigenii

norma

normula

Stratiomys discaloides Curran, 1922

(Fig. 120)

Description. - Puparium. - Size: length 31 mm., width 6.8 mm. Head and body segments dark brown; faint dark markings at basal margin of body segments. Other characters as given in key to species.

Biology. - No data are available for this species.

Material Examined. - MONTANA: Harlan Gulch, Rav. County, 9.I.1932, C.B. Philip, 1 broken puparium (W.S.U.).

Stratiomys spp.

(Figs. 21, 106, 107, 108, 109 and 110)

Description. - Puparium. - Size: length 31.3 - 41.0 mm., width 4.9 - 6.0 mm. Color varying from greyish-brown to dark brown; markings same as for _S. discaloides_. Other characters as given in key to species.

Biology. - See Biology section in this paper.

Material Examined. - _Stratiomys adelpha_ Steyskal - NEW YORK: Ithaca, Decker Pond, 27.III.1950, H.H. Schwardt, 1 puparium (W.S.U.); SASKATCHEWAN: Watson, 15.V.1956, M.E. Taylor, 5 puparia (D.R.L.S.). _Stratiomys badia_ Walker - ALBERTA: 4 miles N. Devon, 16.V.1961, G. Pritchard,

1 puparium (M.W.M.), Banff National Park, Mt. Ishbel, 14.VI.1960, Ball, Madge and McFadden, 1 larva, 1 puparium from under moss, elevation approx. 6000' (M.W.M.). Stratiomys barbata Loew - MANITOBA: Churchill, 16.VII.1949, 2 puparia (C.N.C.); ALBERTA: Banff National Park, Mt. Ishbel, 14.VI.1960, Ball, Madge and McFadden, 1 puparium, elevation approx. 6000' (M.W.M.). Stratiomys meigenii Wiedemann - KANSAS: Manhatten, 8.II.1936, H.H. Schwardt, 2 puparia (W.S.U.). Stratiomys norma Wiedemann - WISCONSIN: T9N Knapps Creek, Richland County, R2W, 10.VI.1954, 529, R.H. Jones, 4 puparia (W.S.U.). Stratiomys normula Loew - LOUISIANA: Baton Rouge (?), 2 puparia (L.S.U.).

Genus Myxosargus Brauer, 1882

Four species of Myxosargus occur in North America but only the puparium of Myxosargus nigricornis Green is known.

Generic Characters

As given in key to genera.

Myxosargus nigricornis Green, 1918

(Figs. 89, 93 and 94)

Description. - Puparium. - Size: length 6.7 - 7.0 mm. (less head and prothorax), mean 6.85 mm.; width 2.0 - 2.1 mm., mean 2.05 mm.

Biology. - No data are available for this species.

Material Examined. - MISSOURI: 5 miles north Vichy, 15.VI.1955, P.J. Spangler, 2 puparia (W.S.U.).

Genus Euparyphus Gerstaecker, 1857

James (1960 A) has divided this genus into two subgenera as follows: Euparyphus (12 species) and Aochletus (2 species). I have seen larvae or

puparia of both species of Aochletus and a single species of Euparyphus.

Generic and Subgeneric Characters

As given in key to genera.

Subgenus Euparyphus Gerstaecker, 1857

Euparyphus limbrocutris Adams, 1903

(Figs. 95, 96 and 100)

Description. - Mature larva. - Size: length 10.6 - 11.2 mm., mean 10.9 mm.; width 2.3 - 2.5 mm., mean 2.4 mm. Prothoracic spiracles located on a medial-lateral projection and extending at least halfway to the dorso-median line of that segment.

Penultimate instar. - Size: length 9.2 - 10.6 mm., mean 9.9 mm.; width 2.0 - 2.1 mm., mean 2.05 mm. Differs from mature larva in that prothoracic spiracles are elevated as high as their basal diameter.

Biology. - No data are available for this species.

Material Examined. - WASHINGTON: O'Sullivan Dam, Grant County, 7.V.1955, J.A. Quist, 2 mature and 2 penultimate instar larvae (W.S.U.).

Subgenus Aochletus Osten Sacken, 1886

Key to Species of Subgenus Aochletus Osten Sacken

1. Prothoracic spiracles distinctly stalked.................... cinctus
- Prothoracic spiracles almost flush with integument...... brevicornis

Euparyphus (Aochletus) cinctus Osten Sacken, 1866

Description. - Puparium. - Size: length 9.5 - 10.5 mm., mean 10.0 mm.; width 2.7 - 2.8 mm., mean 2.73 mm. Other characters as given in key to species.

Biology. - No data are available for this species.

Material Examined. - CALIFORNIA: Topanga Canyon, Los Angeles County, 10.V.1953, 3 puparia (W.S.U.).

Euparyphus (Aochletus) brevicornis Loew, 1866

(Figs. 97, 98 and 102)

Description. - Instar No. ?. - Size: length 4.5 - 5.3 mm., mean 4.93 mm., width 1.3 - 1.7 mm., mean 1.50 mm. Other characters as given in key to species.

Biology. - Larvae have been collected from springs in Yellowstone National Park. No mention is given regarding the type of spring other than the location.

Material Examined. - WYOMING: Mammoth, Yellowstone National Park, 25.I.1956, J.R. Murphy, 3 early instar larvae from a cavern spring (W.S.U.), Mammoth, Yellowstone National Park, 20.VI.1956, J.R. Murphy, 6 larvae from hillside springs (W.S.U.).

Discussion. - The difference or degree or difference exhibited by larvae in this subgenus seems to indicate that perhaps Aochletus should be given full generic status. Of course a complete study of both adults and larvae of Aochletus would have to be undertaken before a decision could be made.

Genus Caloparyphus James, 1939

James (1960 A) lists eleven species for this genus in North America. Associated larvae or puparia have been collected for five species, including one unnamed species.

Generic Characters

As given in key to genera.

Key to the Species of Caloparyphus James

1. Venter of seventh abdominal segment without strong sclerotized hooks .... sp.
- Venter of seventh abdominal segment with strong sclerotized hooks 2
2. Sclerotized hooks half the length of seventh abdominal segment .... amplus
- Sclerotized hooks less than half the length of the seventh abdominal segment 3
3. Prothoracic spiracle oval-shaped, diameter at widest point twice that of the elevation; four setae in mesothoracic leg group... .... major
- Prothoracic spiracle varying in shape but elevation approximately equal to basal diameter; number of setae in mesothoracic leg group other than four 4
4. Three setae in mesothoracic leg group .... tetraspilus
- Five setae in mesothoracic leg group .... crotchi

Caloparyphus sp.

(Figs. 113, 116 and 119)

Description. - Puparium. - Size: length 12.4 - 13.4 mm., mean 12.88 mm.; width 2.5 - 3.2 mm., mean 2.90 mm. Other characters as given in keys to genera and species.

Biology. - Larvae of this species were collected from a sphagnum bog located part way up a mountain (elevation approximately 6000 feet).

Material Examined. - ALBERTA: Banff National Park, Mt. Ishbel, 14.IV.1960, Ball, Madge and McFadden, 5 puparia (M.W.M.).

Caloparyphus amplus (Coquillett), 1902

(Figs. 123, 128, 129, and 132)

Description. - Mature larva. - Size: length 7 mm. or under; width 1.0 - 1.4 mm., mean 1.2 mm. Dorsum of body segments with short blunt setae. Other characters as given in key to species.

Biology. - No data are available for this species.

Material Examined. - CALIFORNIA: Sespe Creek, Ventura County, 15.VI.1948, W.W. Wirth, 20 larvae (U.S.N.M.).

Discussion. - Accurate measurements of length were unobtainable due to improper preservation of the specimens.

Caloparyphus major (Hine), 1901

(Figs. 112, 115 and 118)

Description. - Mature larva. - Size: length 9.6 - 12.1 mm., mean 10.94 mm.; width 2.7 - 2.9 mm., mean 2.8 mm. Other characters as given in key to species.

Biology. - Larvae of this species were collected from moss on a

large floating board in a cold, spring-fed roadside pool.

Material Examined. - BRITISH COLUMBIA: Pole No. $\frac{187}{18}$, Route 3, 9.VI.1960, Ball, Madge and McFadden, 5 larvae, 3 puparia (M.W.M.).

Caloparyphus tetraspilus (Loew), 1866

(Figs. 111, 114 and 117)

Description. - Mature larva. - Size: length 9.5 - 11.0 mm., mean 10.25 mm.; width 1.8 - 2.3 mm., mean 2.05 mm. Other characters as given in key to species.

Biology. - Larvae of this species were collected on a sandy lake beach under decaying vegetation and other debris at the water's edge.

Material Examined. - ALBERTA: Dilberry Lake, 54° 34' 30" N. Latitude, 110°, 60' 45" W. Longitude, 5.VI.1960, Ball, Madge and McFadden, 2 larvae (M.W.M.).

Caloparyphus crotchi (Osten Sacken), 1877

(Figs. 126, 130 and 133)

Description. - Puparium. - Size: length specimen broken, impossible to measure accurately but close to 15 mm., width 3.4 mm. Other characters as given in key to species.

Biology. - No data are available for this species.

Material Examined. - COLORADO: Fort Collins, 4.VIII.1910, 1 puparium (W.S.U.).

Genus Hedriodiscus Enderlein, 1914

James (1960 A) lists seven species for this genus in North America. Only the larva of Hedriodiscus vertebratus (Say) is known.

Hedriodiscus vertebratus (Say), 1824

(Figs. 88 and 92)

Description. - Puparium. - Size: length 19 mm., width 2.7 mm. Other characters as given in key to genera.

Biology. - James (1960 B) reported that larvae of this species live among floating vegetation in small streams. They feed on microorganisms, algae and the soft parts of plants.

Material Examined. - Locality (?), 1.VII.1938, larva from weedy lake, 1 puparium (W.S.U.).

Genus Odontomyia Meigen, 1803

James (1960 A) has divided this taxon into three subgenera as follows: Catasina (9 species), Odontomyiina (7 species) and Odontomyia (14 species). The character combinations of the immature stages seem to support this classification.

Subgenus Catasina Enderlein, 1914

Odontomyia pubescens (Day), 1882

(Figs. 87, 90 and 91)

Description. - Puparium. - Size: length 13.8 - 17.0 mm., mean 15.80 mm.; width 2.7 - 3.6 mm., mean 3.1 mm. Other characters as given in key to genera.

Biology. - Larvae of this species have been collected from moss-covered logs (in boggy areas), from under stones at water's edge and from the margins of marshy areas.

Material Examined. - ALBERTA: Beaverhills Lake near Tofield,

21.V.1960, G.E. Ball, 1 puparium (M.W.M.), Flatbush, 12.V.1960, M.W. McFadden, 1 larva, 1 puparium (M.W.M.), Dilberry Lake, 54° 34' 30" N. Latitude, 110° 60' 45" W. Longitude, 5.VI.1960, Ball, Madge and McFadden, 1 puparium (M.W.M.); SASKATCHEWAN: Saskatoon, 15.V.1949, A.R. Brooks, 1 puparium (D.R.L.S.).

Subgenus Odontomyiina Enderlein, 1930

Odontomyia virgo (Wiedemann), 1830

(Figs. 99 and 103)

Description. - Puparium. - Size: length 15 mm. (less head and prothorax), width 3.50 mm. Four white vittae on dorsal surface of body segments, inner two narrow; penultimate segment half as long as apical segment. Other characters as given in key to genera.

Biology. - Larvae of this species were collected by me from shore debris at the edge of a small pond.

Material Examined. - ALBERTA: 4 miles North Devon, 10.V.1961, M.W. McFadden, 1 puparium, 1 early instar larva (M.W.M.).

Subgenus Odontomyia Meigen, 1803

Key to the Species of the Subgenus Odontomyia Meigen

1. Venter of sixth and seventh abdominal segments with multiple hooks .... occidentalis
- Venter of sixth and seventh abdominal segments with a single pair of hooks 2
2. Dorsum with two broad vittae extending length of body but dividing into four vittae on apical segment .... cincta

- Vittae in different pattern; body segments with fine white pubescence .... communis

Odontomyia occidentalis James, 1936

(Figs. 136, 137 and 139)

Description. - Puparium. - Size: length 20 mm., width 3.5 mm. Other characters as given in key to species.

Biology. - Larvae of this species have been collected from hot springs.

Material Examined. - Sleeping Child Hot Springs, reared 28.VI.1930, 2 puparia (W.S.U.).

Discussion. - The mensural data given above were taken directly from the puparia. These specimens had the apical segments turned up in the typical manner making accurate measurements an impossibility.

Odontomyia cincta Olivier, 1811

(Figs. 127, 131 and 134)

Description. - Mature larva. - Size: length 18.5 - 20.0 mm., mean 19.25 mm.; width 3.5 - 3.9 mm., mean 3.7 mm. Other characters as given in key to species.

Biology. - Larvae of this species have been collected from a peat bog and from a pool of unidentified type.

Material Examined. - OHIO: Delaware County, 29.VII.1940, 1 larva (O.S.U.); WISCONSIN: Dane County, University of Wisconsin Arboretum, 22.V.1954, R.H. Jones, 1 puparium (W.S.U.).

Odontomyia communis James, 1939

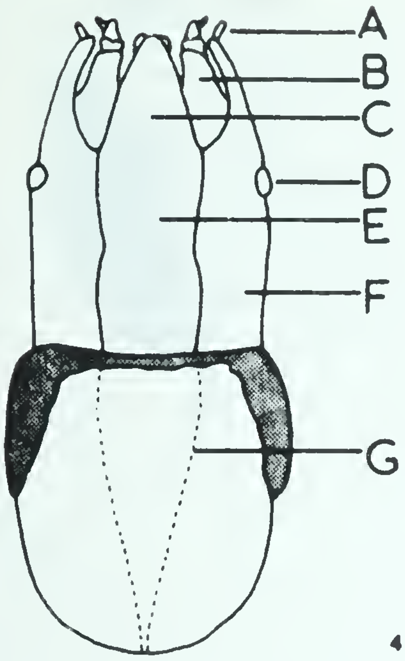
(Figs. 141 and 143)

Description. - Mature larva. - Size: length 19 - 21 mm., mean 20 mm.; width 2.9 - 3.6 mm., mean 3.25 mm. Other characters as given in key to species.

Biology. - Larvae of this species have been collected from 5% saline water in Death Valley.

Material Examined. - CALIFORNIA: Bad Water, Death Valley, 1.IV.1958, D.P. Furman, 2 larvae (W.S.U.).

IX PLATES



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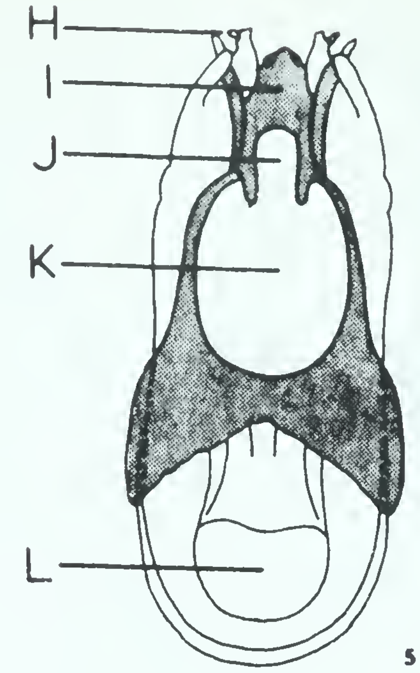

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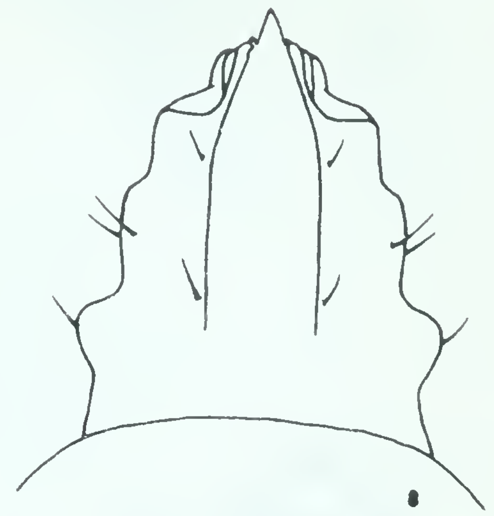

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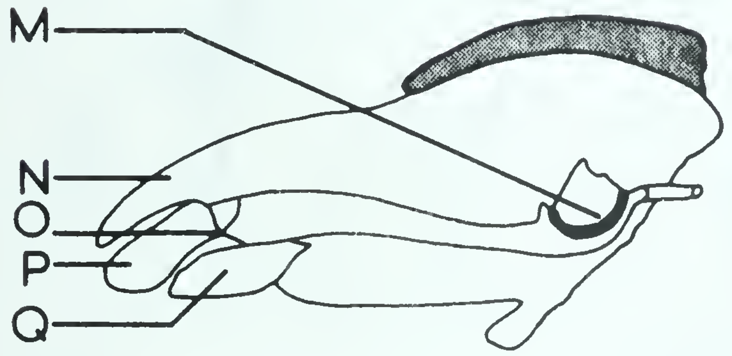

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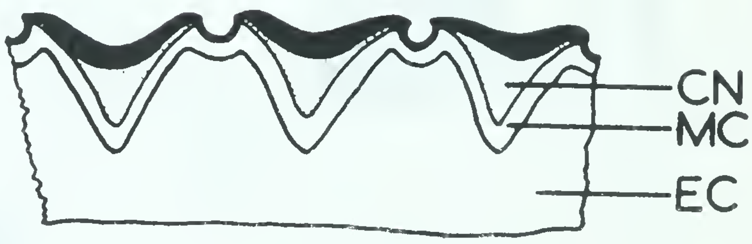

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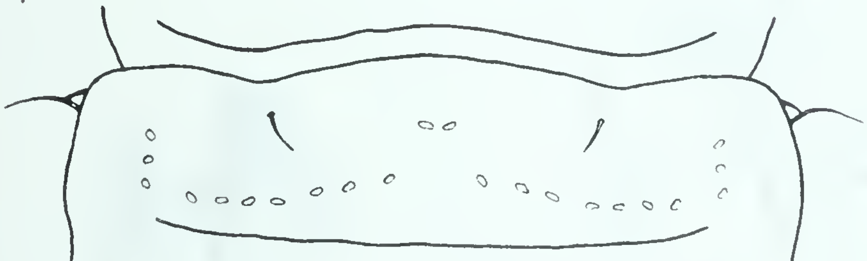

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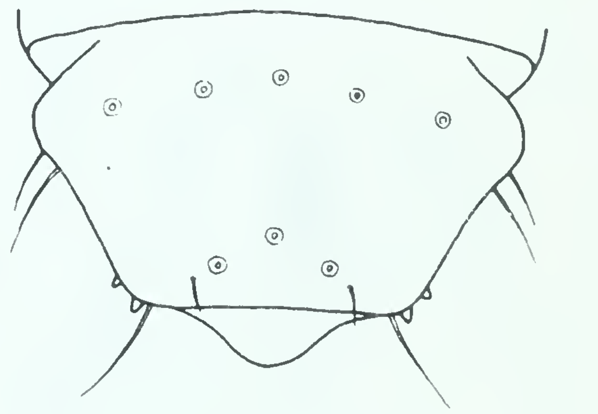

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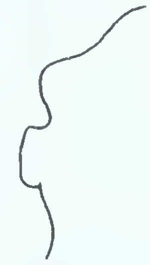

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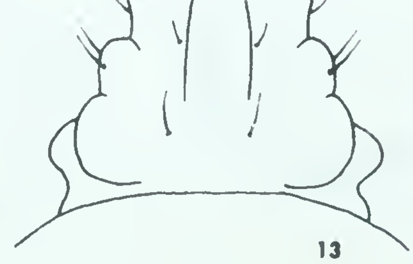

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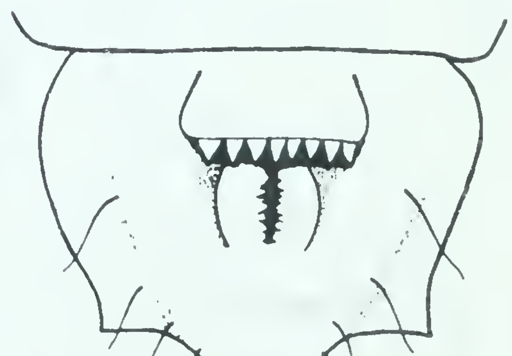

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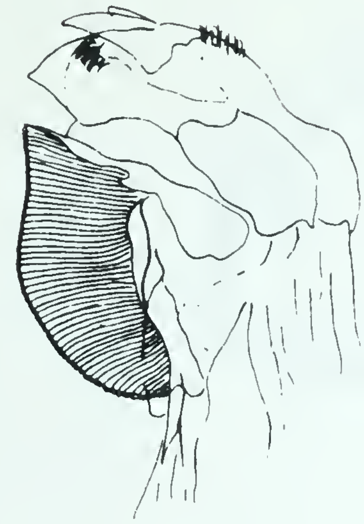

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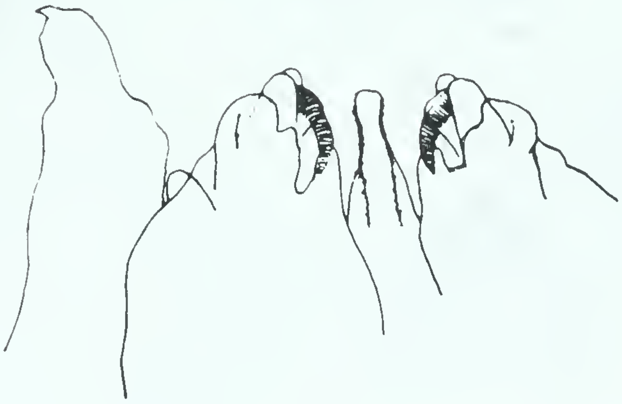

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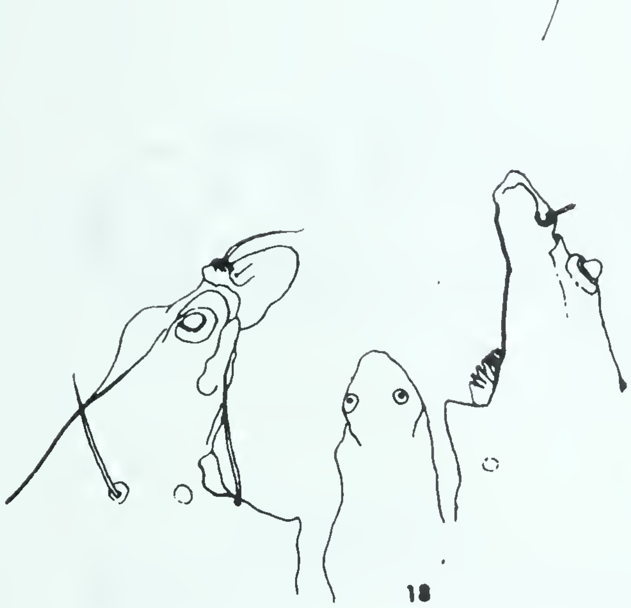

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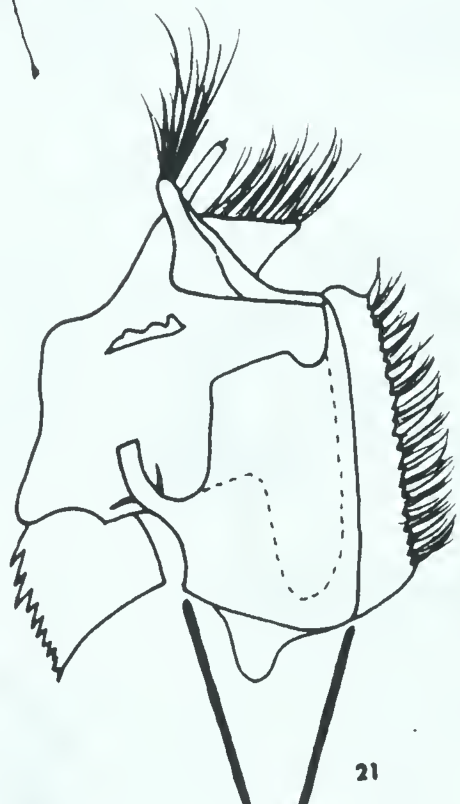

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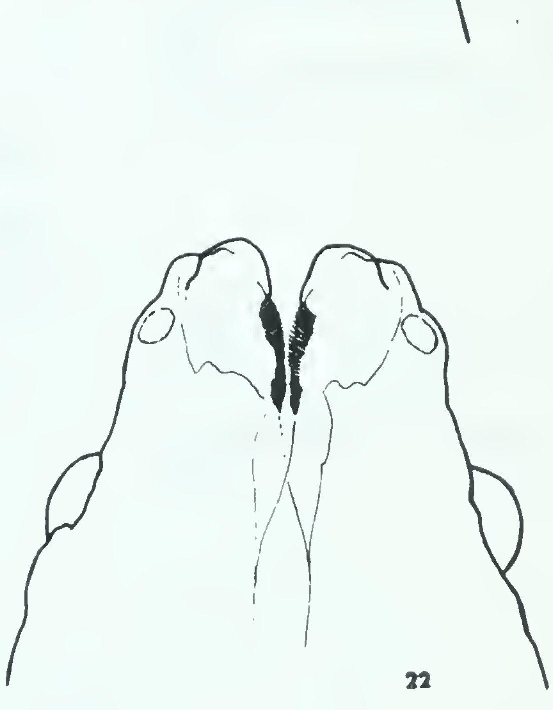

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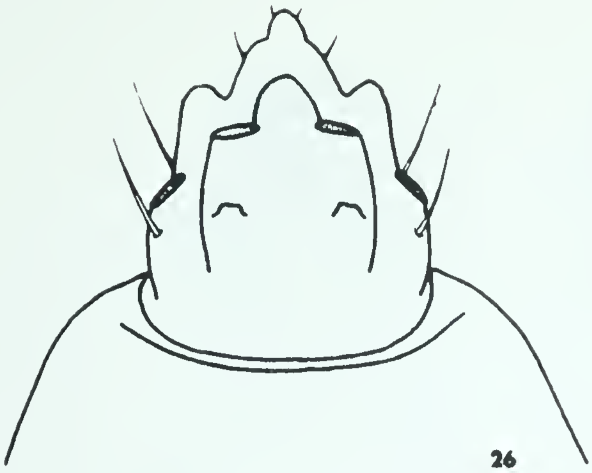

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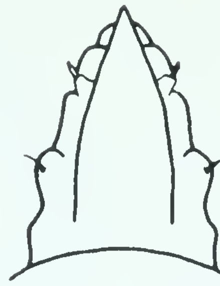

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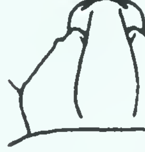

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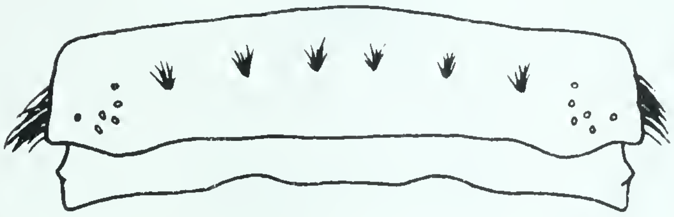

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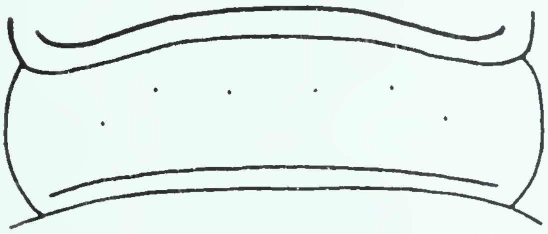

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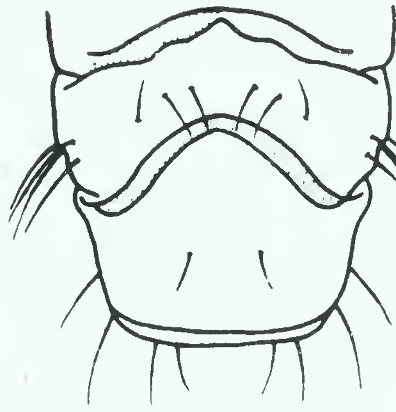

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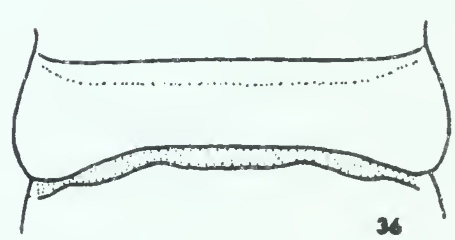

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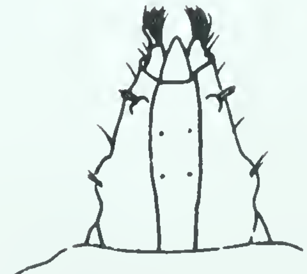

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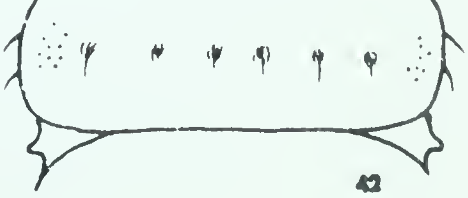

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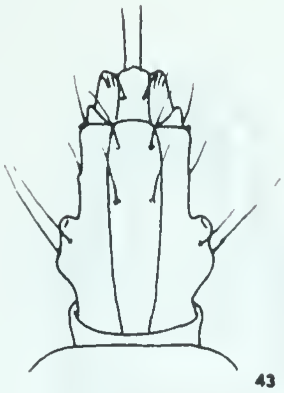
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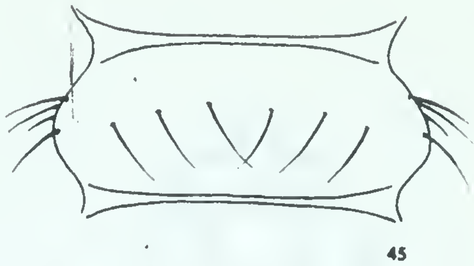
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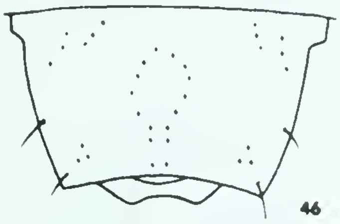
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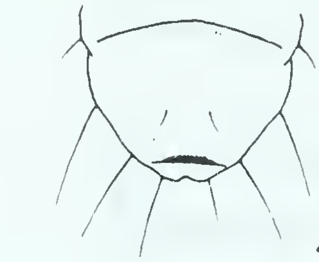
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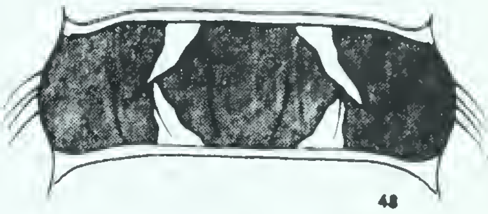
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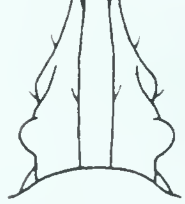
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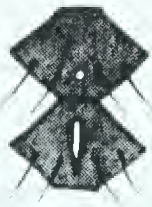
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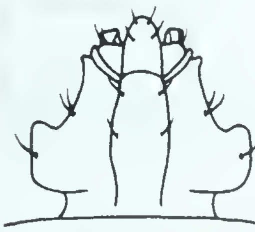
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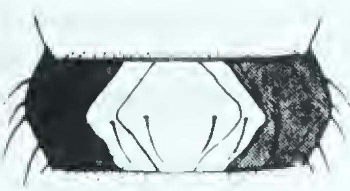
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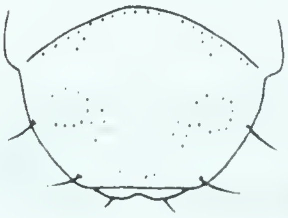
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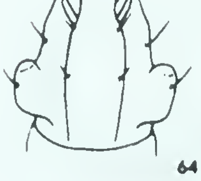
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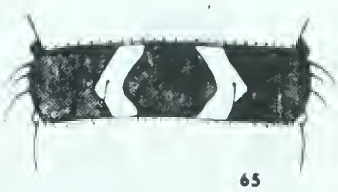
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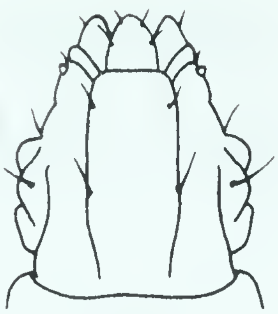
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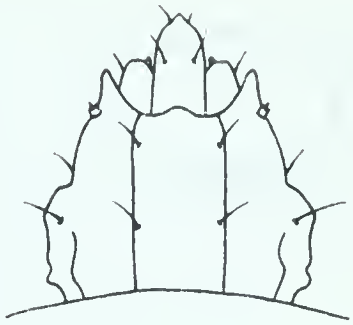
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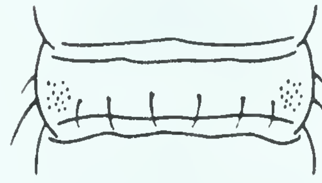
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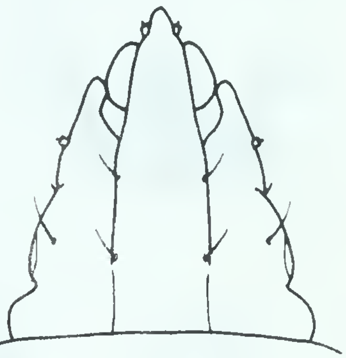
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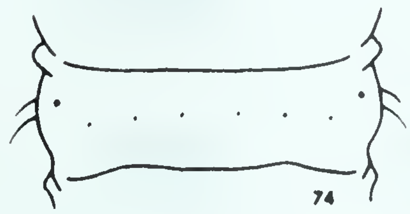
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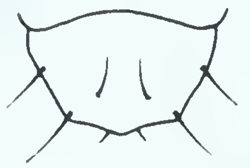
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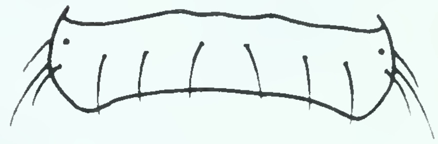
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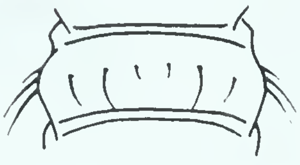
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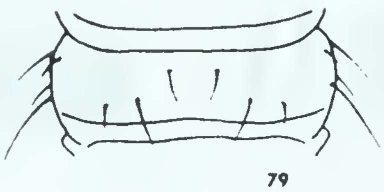
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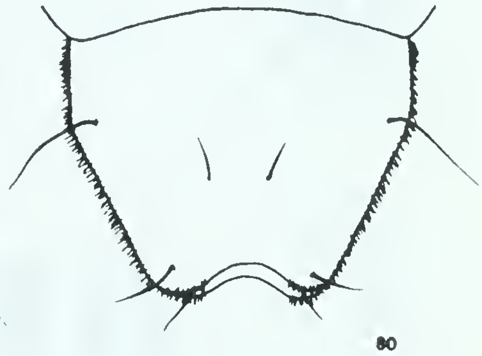
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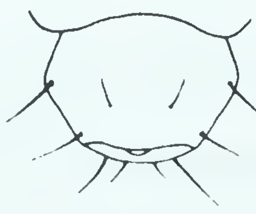
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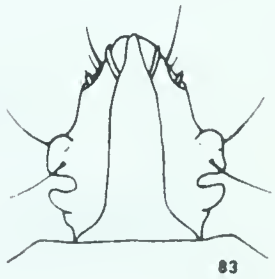
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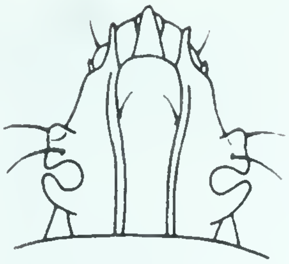

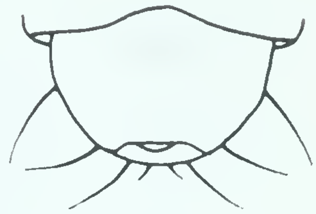

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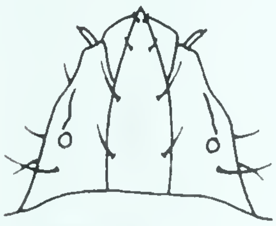
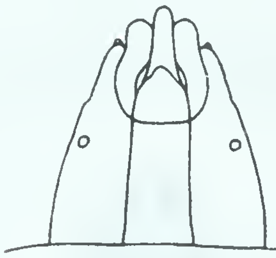
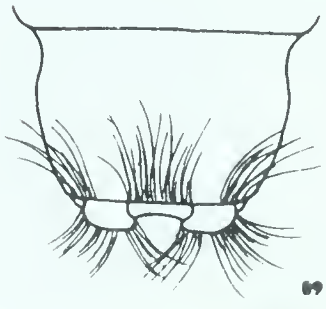

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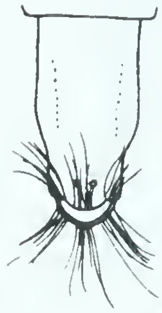
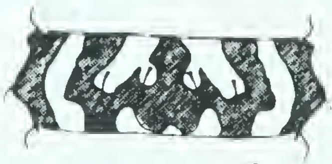


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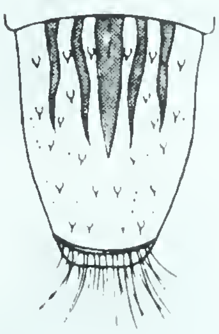
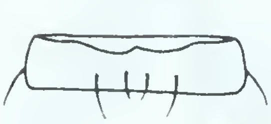
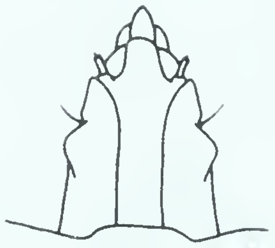
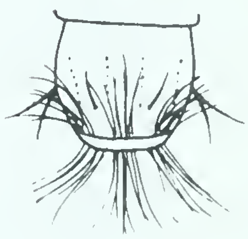

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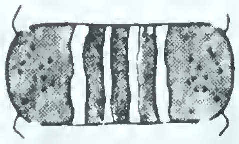
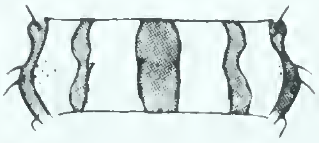
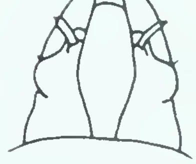

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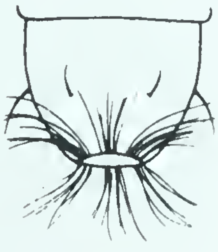
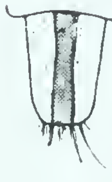
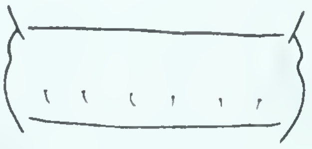
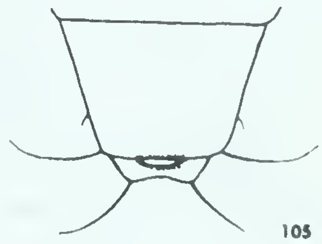

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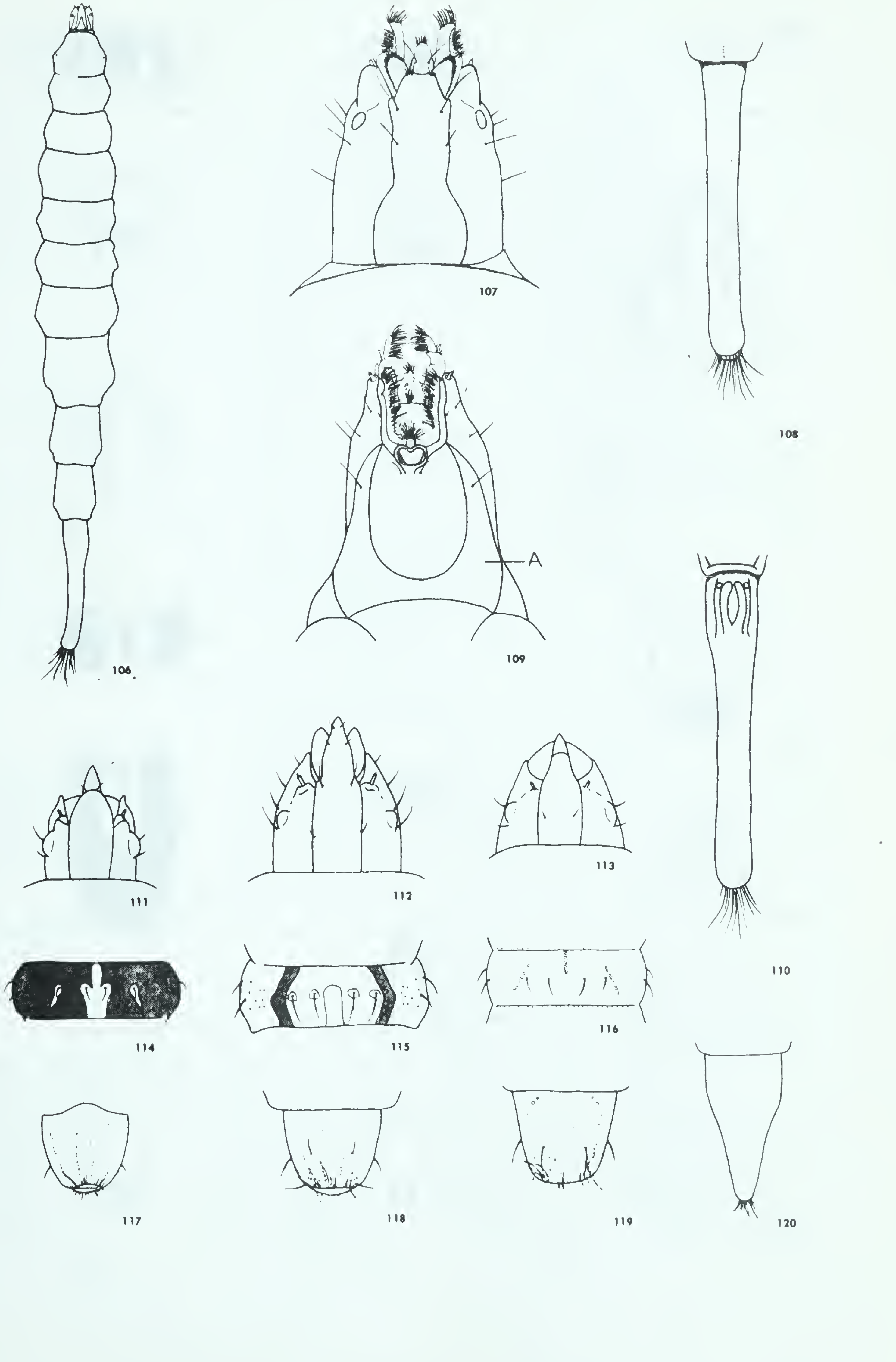
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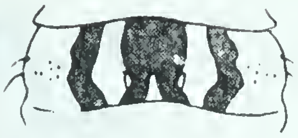
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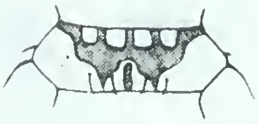
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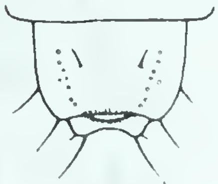
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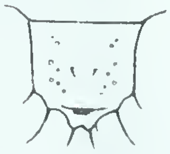
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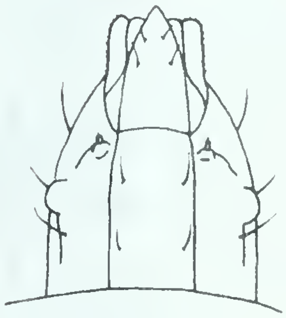
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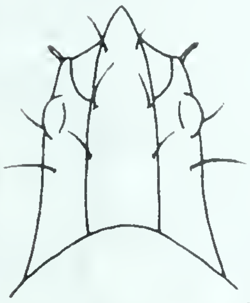
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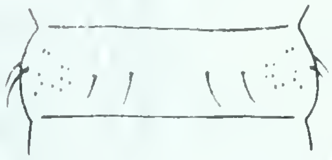
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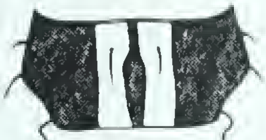
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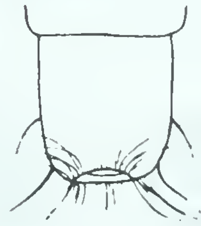
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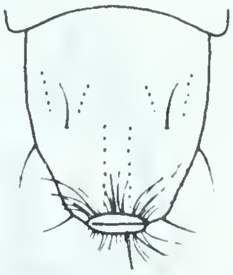
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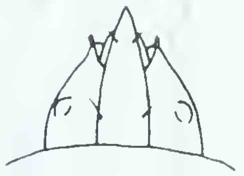
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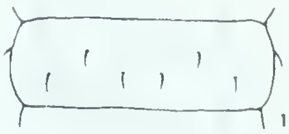
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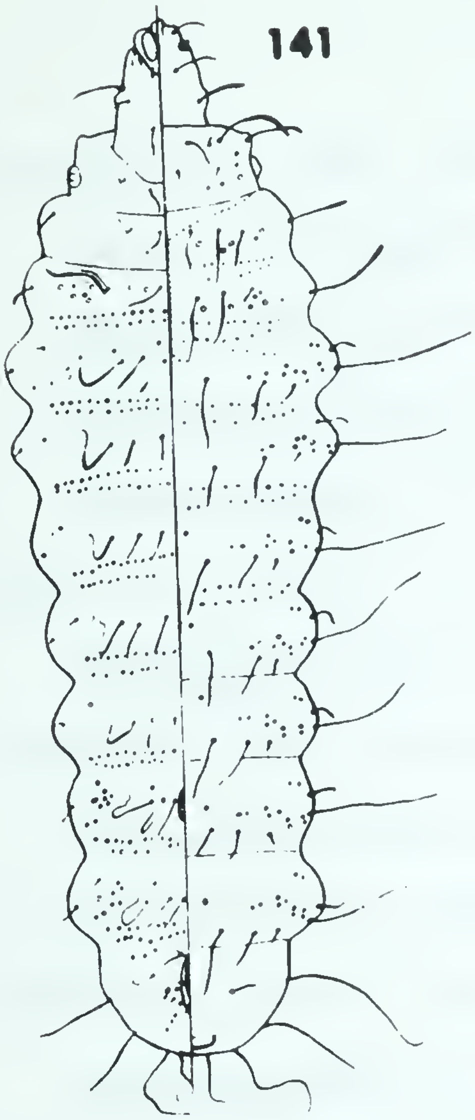
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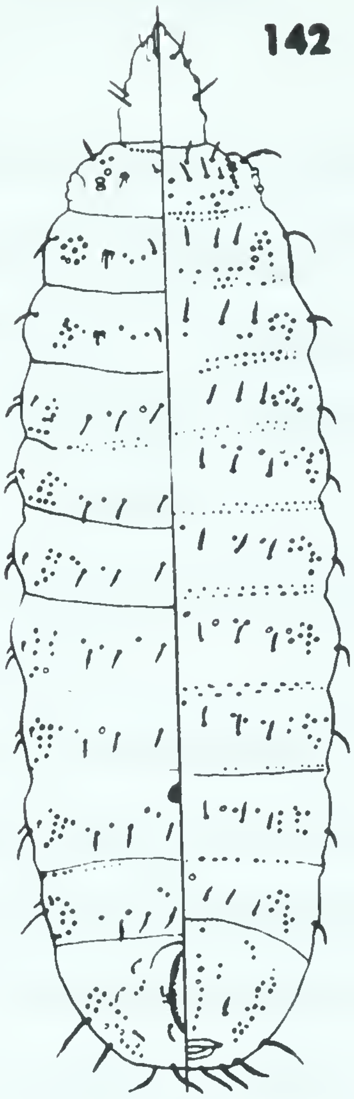
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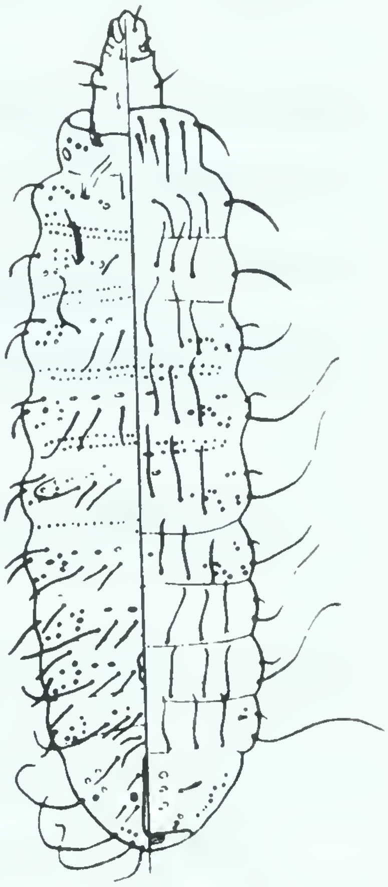
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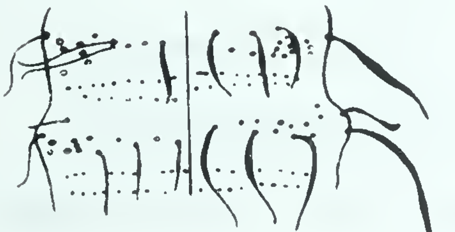
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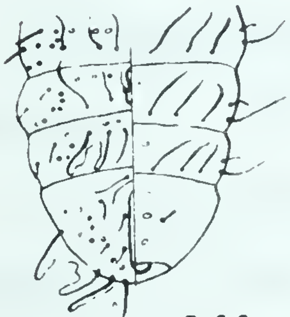
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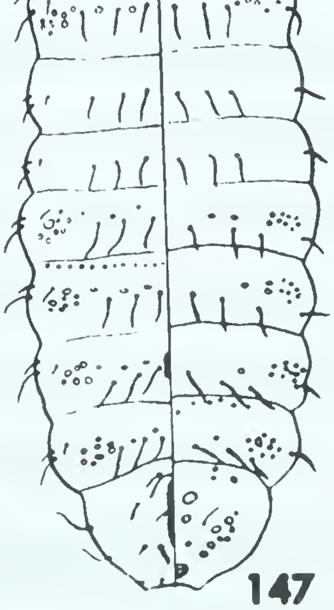
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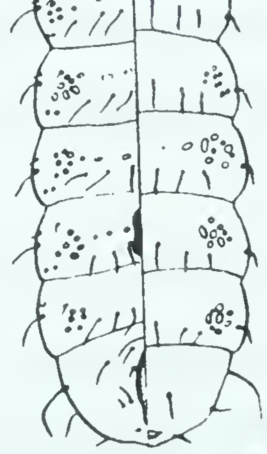
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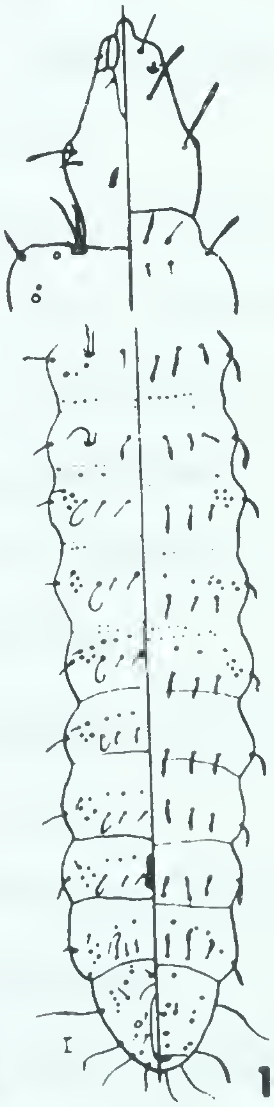
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Stände. Entomologischer Verein in Breslau Zeitschrift, 2: 1-24.

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Zeller, P. C. 1842. Dipterologische Beiträge. Isis von Oken, 11: 807-847.

Zetterstedt, J. W. 1851. Diptera scandinaviae disposita et descripta. Lund. Verfasser. Volume 10 of 14 volumes.

XII. Appendix A.

CHRONOLOGICAL LISTING OF WORKS DEALING WITH LARVAE OF STRATIOMYIDAE

1720 Frisch, J.L. Note on larva of *Stratiomys chamaeleon*.

1737 Swammerdam, J. Larva of *Stratiomys chamaeleon*. Structure and life history described accurately and in detail with figures under the name *Asilus*.

1742 Réaumer, R.A.F. de. Paper not seen by author.

1778 Geer, C. de. Note on larva of *Odontomyia hydroleon*.

1793 Schrank, F. Note on larva of *Stratiomys chamaeleon*.

1806 Sparrman, A. Paper not seen by author.

1825 Fargeau, S. and J.G. Serville. Description of *Pachygaster* sp. by Macquart quoted here.

1828 Roser, C.L.F. von. Larva of *Xylomyia varia* (*Xylophagus varius*) described.

1829 Schilling, P.S. Larvae of *Pachygaster ater* found under the bark of *Pinus silvestris*.

1832 Lyonet, P. Research on anatomy and morphology of the larva of *Sargus cuprarius*.

1834 Bouché, P.F. Note on larvae of *Chrysomyia polita* and *Sargus cuprarius*.

Roser, C.L.F. von. Larvae of *Chrysomyia formosa* found under stones, also some notes on the larvae of *Sargus cuprarius* and *Ephippium thoracium*.

1837 Wesmael, C. Notes on the metamorphosis of *Subula* (*Xylomyia*) *marginata* Meigen or *Subula maculata*.

1840 Westwood, J.O. Immature stages of Subula maculata found in dry rotten tree in the New Forest and reared through to the adult stage. Notes on larvae of Ephippium thoracium, Pachygaster sp. and Sargus cuprarius are also given.

1841 Dufour, L. Note on larva of Pachygaster mesomelas.

1842 Zeller, P.C. Larva of Odontomyia argentata found in fall, winter and spring under fallen leaves in moist alder.

1844 Markel, F. Note on larva of Clitellaria ephippium.

1846 Breml. Note on larvae of Oxycera spp.

Dufour, L. Note on larva of Subula citripes.

---------. Larvae of Sargus cuprarius found in an ulcer of an elm tree.

1847 Dufour, L. Metamorphosis of Subula citripes and other species in this genus.

1848 Scholz, H. Larva of Stratiomys longicornis found in a slough; larva of Chrysomyia polita found in cow dung and a few additional notes are given for the larvae of Ephippium thoracium, Odontomyia viridula and Pachygaster ater.

1851 Walker, F. Note on larva of Beris chalybeata.

Zetterstedt, J.W. Paper not seen by author.

1853 Heeger, E. Figure of Pachygaster ater.

1856 Heeger, E. Biology of Oxycera meigenii and Oxycera trilineata are given.

1857 Haliday, A.H. Notes on biology of larvae.

------------. Notes on biology of larvae.

1858 Heeger, E. Metamorphosis of Subula varia.

1860 Leydig, F. Concerning calcium deposits in the integument of larvae in this family.

Cornelius, C. Development of Sargus formosus.

1861 Bellardi, L. Larvae of Hermetia illucens found in privies.

1864 Schiner, J.R. Note on larva of Beris chalybeata.

1866 Jaennicke, F. Odontomyia ornata bred from a larva found in water near Frankfort. Larva of Ephippium thoracium taken from a nest of Formica fuliginosa.

1867 Goureau, C. A note on the larva of Subula sp.

Kawall, J. H. C. Transformation of Stratiomys strigata briefly described, also a larva found among black ants in an old fallen Pinus silvestris.

1868 Damianitsch, R. Larva of Xylophagus ater found under bark of alder; metamorphosis described.

1869 Brauer, F. Characterizes the larvae of the Diptera with the object of showing how they may be classified and especially how they support the system founded by Schiner upon Brauer's indications. The classification, founded upon the characters of the larvae, adapted by Brauer is as follows: the Stratiomyidae along with the Xylophagidae, Coenomyidae, Tabanidae and Leptidae are placed in the Orthorrhapha-Brachycera, Tribe Cyclocera.

1870 Perris, E. Note on larva of _Pachygaster pini_.

1871 Packard, A.S. Larva of unknown _Stratiomys_ found in salt water.

1876 Ganin, M. Larvae of _Stratiomys_ compared with _Anthomyia_.

Kunckel d'Herculais, J. Morphology of the nervous system in larvae of this family.

1880 Laxer, A.G. Larvae of _Stratiomys_ in winter.

Freidenfels, E. Note on the larva of _Stratiomys longicornis_.

1881 Brongniart, C.J.E. Larva of _Stratiomys_ found in the quaternary tuffs at Bernouville.

1882 Viallanes, H. Nerves in the skin of a larva of _Stratiomys_ described.

-------------. A histological account of the integument, nerve terminations, etc., in the larvae of _Stratiomys_.

Griffith, H.G. and A.S. Packard. Larvae of _Stratiomyia_ sp. found in a hot spring in Colorado.

Osten Sacken, C.R. From arguments drawn from the adults, larvae, mode of pupation and nervous system, the correct classification of _Subula_ is determined.

1883 Beling, Th. Metamorphosis of _Sargus cuprarius_ and _Chrysomyia polita_.

Brauer, F. After a general introduction the author discusses the characters of the dipterous larvae, and their systematic importance and regards his previous views on the classification of Diptera into two main sections according to the greater or lesser differentiation of the

head capsule of the larva. Stratiomyidae classified as follows:

Suborder I -- Orthorrhapha

Section II -- Orthorrhapha-Brachycera

Tribe ii -- Platygenya

Group I -- Homoeodactyla

(a.) -- Notacantha

Family -- Stratiomyidae

" -- Xylophagidae

Handlirsch, A. Larva of Chlorisops (Actina) tibialis described; additional remarks on larvae of allied genera.

Pearson, A.W. Stratiomys larva occurring in sea water.

1885 Viallanes, H. Histological treatment of the nervous system of a larva of Stratiomys.

1892 Henneguy, F. and A. Binet. Microscopic study of the nervous system of Stratiomys longicornis.

1893 Townsend, C.H.T. Pupa and puparium of Subula pallipes described.

1895 Baker, C.F. Note on the larva of Subula pallipes.

Johnson, C.W. Larvae of Stratiomys found in thermal springs.

Miall, L.C. Life history of Stratiomys given in detail.

1896 Froggat, W.E. Larvae and metamorphosis of Ephippium albitarsus.

Mik, J. Note on Stratiomys chamaeleon.

1898 Hart, C.A. Larva of _Odontomyia cincta_, _Odontomyia vertebrata_ and _Stratiomyia norma_ described.

1899 Austen, E.E. Discourse on proper classification of _Xylomyia_.

Florentin. Habits of larva of _Stratiomys chamaeleon_.

Riley, C.V. and L.O. Howard. Larva of _Hermetia illucens_ found in beehives.

1900 Vaney, C. Note on the malpighian tubules in the larva of _Stratiomys_.

1901 Needham, J.G. and Betten, G. Description of larva of _Stratiomys badius_.

1904 Howard, L.O. Biology of larvae in this family.

Plotnikow. Notes on moulting and elements found in the integument of stratiomyid larvae.

1906 Johnson, C.W. Description of _Zabrachia polita_.

1907 Lundbeck, W. A general account of the eggs, larvae and pupae occurring in Denmark.

1908 Williston, S.W. Description of eggs, larvae and pupae.

1909 Verrall, G.H. General description of family with some notes on metamorphosis by D. Sharp. Key to sub-families based on larval characters included.

1910 Grünberg, K. General description of larvae with notes on biology.

Jusbaschjanz, S. Note on the embryonic development of Stratiomyidae.

1911 Cros, A. Note on the larva of _Stratiomys anubis_.

Meijere, J.C.H. de. Note on the larva of _Ptilocera quadridentata_.

1913 Fanthom, H.B. and A. Porter. Note on a flagellate parasite of the larvae of _Stratiomyia_ _chamaeleon_ and _Stratiomyia_ _potamida_, with additional remarks on biology of the hosts.

Schmidt, R. Notes on some aquatic stratiomyid larvae.

1914 Tragardh, I. Larva of _Pachygaster_ _minutissima_ found under bark.

1916 Dunn, L.H. Larvae of _Hermetia_ _illucens_ found on a human cadaver.

Engel, E.O. Description and biology of _Hermione_ (_Oxycera_) _amoena_.

Meijere, J.C.H. de. General account of larvae.

1917 Greene, C.T. Larva of _Neopachygaster_ _maculicornis_ is described.

Malloch, J.R. Classification and biology of larvae.

1920 Irwin-Smith, V. Biology of _Metoponia_ _rubriceps_.

Kruper, F. Note on calcium deposits found in integument of larvae.

Myers. Paper not seen by author.

1921 Irwin-Smith, V. Experiments in rearing _Metoponia_ _rubriceps_.

Johannsen, O.A. Larva of _Oxycera_ or _Euparyphus_ _tenuicornis_ is described.

1922 Johannsen, O.A. Stratiomyid larvae and puparia of the north-eastern states.

1923 Irwin-Smith, V. On the structure of the mouthparts and pharynx of the larva of _Metoponia_ _rubriceps_.

Lenz, F. Larvae of _Oxycera_, _Nemotelus_ and _Beris_ described with notes given on biology.

1924 Brues, C.T. Larva of *Stratiomys* found in a thermal spring.

1925 Bischoff, W. Morphology of the head capsule of larvae in the suborder Brachycera.

Müller, G.W. Note concerning calcium deposits found in the integument of the larva of *Sargus cuprarius*

Vimmer, A. General account of larvae.

1926 Greene, C.T. Description of larva of *Xylomyia pallipes*.

Copello, A. Biology of *Hermetia illucens*.

Lenz, F. Stratiomyid larvae found in salt water.

Seguy, E. Key to larvae (after Brauer).

1928 Brues, C.T. Larvae of *Stratiomys* found in hot springs.

Engelhardt, G.P. Note on breeding *Hermetia aurata*.

Lindner, E. Larva of *Rhingiopsis enderleini* described.

1929 Buxton, P.A. Notes on larvae of four species of Stratiomyidae from Samoa.

Ricardo, G. Larvae of Stratiomyidae from Samoa.

1930 Borgmeier, T. Note on the larva of *Hermetia illucens*.

1931 Raff, J.W. Note on the larva of *Chiromyza australis*.

1932 Brues, C.T. Larvae of Stratiomyidae found in thermal springs.

1933 Mathur, R.N. Bionomics of *Odontomyia cyanea*.

1934 Fuller, M.E. Biology and morphology of *Actina incisuralis*.

Kuster, K.C. Study on general biology, morphology and respiration in certain species of *Stratiomyia* and *Odontomyia*.

1935 Johannsen, O.A. General account of aquatic stratiomyids

including a key to species.

1936 Kuster, K.C. Distributional variation in ganglionic tracheae in the larva of *Odontomyia cincta*.

1937 Collart, A. Biology of Stratiomyid larvae.

Engel, E.O. and A. Cuthbertson. Biology of stratiomyid larvae.

1938 Lindner, E. Descriptions and biology of palaearctic larvae.

1939 Goidanich, A. Paper not seen by author.

1943 Wesenberg-Lund, C. Biology of larvae.

1945 Hrbáček, J. Paper not seen by author.

1947 James, M.T. Note on *Hermetia illucens* causing intestinal myiasis.

1948 Bertrand, H. Note on two larvae belonging to the genus *Hermione*.

1949 Cook, E.F. Morphology of the head capsule of *Odontomyia*.

1951 Hudson, G.V. Paper not seen by author.

Peterson, A. Descriptions and biology of some nearctic larvae.

Schremmer, P. Note on the biology of the larvae of *Hermione* (*Oxycera*) *calceata* and *Hermione meigenii.*

-------------. Morphology of head parts of *Stratiomys chamaeleon*.

1952 Hennig, W. Descriptions, biology and keys to larvae.

1956 Wirth, W.W. Biology and keys to aquatic larvae occurring in the western states.

1957 James, M.T. Description of larva of *Cyphomyia* and its significance in classification.

1959 Brindle, A. Key to larvae occurring in England with notes on biology.

Furman, D.P., R.D. Young and P.E. Catts. Biology and economic significance of *Hermetia illucens*.

James, M.T. Key to larvae of Stratiomyidae.

1960 James, M.T. Biology of Stratiomyid larvae.

1961 Kraft, K. and E.F. Cook. Keys and descriptions for larvae of subfamily Pachygasterinae.

1962 James, M.T. Larva of *Dicyphoma schaefferi* described.

Appendix B

Detailed Collecting Data

SUBFAMILY SARGINAE

Genus *Ptecticus* Loew

Ptecticus trivittatus, Say, 1829

GEORGIA: Silver lake, Bradley, 7 larvae from decaying garbage and rotting paper; ILLINOIS: Urbanna, 3.VIII.1942, H.H. Ross, 14 larvae; MARYLAND: Cabin John Bridge, 31.VII.1913, Barber and Shannon, 11 larvae from fungus (*Laetiporus speciosus*); NORTH CAROLINA: Faison, 25.VIII.1950, P.O. Richter, 5 larvae from watermelon, Faison, 14.X.1952, Dogger and Howden, 1 larva from decaying vegetables, McCulley's, 20.I.1951, Weisman, 3 larvae from watermelon rinds; OHIO: O.A.E.S. dump, 22.VIII.1943, 17 larvae from decaying tomatoes.

Genus *Microchrysa* Loew

Microchrysa polita (Linnaeus), 1758

COLORADO: Woodland Park, Station 4, 4.VIII.1943, J.A.R. and H.H. Ross, 3 larvae from cattle droppings; MASSACHUSETTS: Amherst, 10.VII.1942, M.E. Smith, 15 larvae, 2 puparia from decaying vegetation; NEW YORK: Ithaca, 8.VII.1915, 4 larvae from cow manure, Ithaca, July 1917, 5 larvae, 3 puparia from decaying rhubarb, Ithaca, 17.VII.1919, 9 larvae; NORTH CAROLINA: Rowan County, 14.XII.1955, C.E. Jernigan, 1 larva from woods trash.

SUBFAMILY HERMETIINAE

Genus *Hermetia* Latreille

Hermetia illucens (Linnaeus), 1758

ARKANSAS: Fayetteville, 27.IX.1927, W.J. Baerg, 3 larvae from kraut; CALIFORNIA: 10 miles E. Rosario Cirio, 29.VI.1938, Ross and Michelbacher, 12 larvae: DELAWARE: Magnolia, X.1958, P.P.B., 10 larvae from polluted water, Primehook Neck, M.S.C., 8 larvae from lima bean cull pile, Thompsonville, 24.X.1957, M.S.C., 1 larva from lima bean refuse pile; FLORIDA: Collection No. 1884 from U.S.N.M., 5 larvae, 1 pupa; GEORGIA: Bissel, 15.IX.1938, 1 larva from rotten potatoes, Camp Stewart, 21.IX.1944, E.R. Willis, 8 larvae taken from pit latrine, Camp Stewart, 6.XII.1944, E.R. Willis, 31 larvae taken from pit latrine; LOUISIANA: Baton Rouge, 30.IX.1959, H.V. Daley, 13 larvae from chicken manure; MARYLAND: Beltsville, 9.VIII.1957, J.C. Hwang, 4 larvae from turkey manure; MISSOURI: St. Louis, 20.VII.1960, C.W. Robinette, 4 larvae; NEW MEXICO: Roswell, 30.VIII.1957, 7 larvae taken from worm bed; NORTH CAROLINA: Clay County, 15.X.1954, extension service, 5 larvae from silo, Clayton County, 5.VII.1959, W. Brooks, 6 larvae from corn pile, Faison, 14.VIII.1952, Dogger and Howden, 9 larvae from rotting pumpkin, Fuguay, 12.IX.1950, 5 larvae from manure, Long Beach, 5.9.1951, 1 larva from refuse, Onslow County, 18.IX.1956, H.E. Scott, 2 larvae from poultry litter, Raleigh, 4.VIII.1941, 8 larvae from garbage, Raleigh, 1.VII.1953, D.M. Weisman, 3 larvae from ensilage, Raleigh 4.IX.1954. W. Spink, 5 larvae, Rockingham, 25.X.1955, M. Farrier, 4 larvae from under caged hens; SOUTH CAROLINA: Clemson, 18.XI.1959, Schroeder and

Skelton, 2 larvae from lab culture (dung), Clemson, 19.XI.1959, 1 larva from manure, Clemson, 30 larvae (no data), Wild Cat Creek, Six Mile, 29.IX.1959, D.H. Peterson, 1 larva; TENNESEE: Knoxville, Harwood, 1 pupal case. WASHINGTON: Everett, 22.VI.1957, F. Johansen, 10 larvae from soy beans in freight car, origin unknown.

SUBFAMILY PACHYGASTERINAE

Genus *Eupachygaster* Kertész

Eupachygaster punctifer Malloch, 1915

DELAWARE: Sussex County, 1952, W.A. Connell, 6 larvae from under bark; NORTH CAROLINA: Auburn, 2.XI.1956, Bowden and Wright, 3 larvae from under bark of oak log, Herring, 23.VIII.1956, C.G. Wright, 1 larva from under bark of oak log, West End, 15.VII.1941, 12 larvae from under bark of pine log.

Eupachygaster fusca Kraft and Cook, 1961

NORTH CAROLINA: Rocky Mountain, 25.III.1954, D.M. Weisman, 20 larvae from under bark of log, OHIO: Wooster, 22.IV.1940, H.R. Dodge, 5 larvae from under willow bark.